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Anttoni Kervinen

Out of earshot and out of sight of the science teacher
An investigation of learning opportunities in outdoor settings

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Abstract

The focus in this dissertation is on students' interactions and science teaching practices in loosely supervised outdoor environments. The aim is to investigate the opportunities of students to participate in science learning in affectively meaningful ways that working away from the teacher can provide, and how these opportunities can be enabled through instructional strategies. The contribution of the dissertation is therefore to contribute to the current understanding of how potentially alienating dimensions of science teaching can be moderated.

To understand students' experiences and interactions in learning settings when the teacher's supervision is not constant, in this dissertation I have investigated student groups conducting fieldwork activities in a forest and teachers who implement fieldwork extensively in their biology courses. The empirical data analyzed comes from video recordings of student groups, mobile messages used in the communication and student and teacher interviews. The empirical analysis focuses on sociocultural phenomena made visible in the interaction of the students and the discursive accounts of the teachers about their outdoor teaching practices.

The results of the dissertation demonstrate a variety of non-conceptual but culturally important ways that students draw on to connect science learning with their everyday experiences and to temporarily overturn the authoritativeness of science. These interactions appear as potential ways to moderate the alienating aspects of teaching while they simultaneously allow students to complete the tasks. Furthermore, the results show which instructional strategies allow students' sense of freedom to be balanced against controlling practices so that the initially uncommon setting is transformed into ordinary schooling for the students.

Overall, the dissertation results should encourage educators and researchers to regard all students' experiences during science lessons as potentially important and valuable. Provided that certain controlling practices ensure there is enough focus on the intended objectives, the loosely supervised learning settings appear to provide authentic opportunities for students to access science learning in affectively meaningful ways.

Keywords: ethnomethodology, outdoor learning, science education, socio-cultural psychology

Helsingin yliopisto, Kasvatustieteellinen tiedekunta
Kasvatustieteellisiä tutkimuksia, numero 84

Anttoni Kervinen

Poissa luonnontieteiden opettajan kuuluvilta ja näkyvistä
Tutkimus oppimisen mahdollisuuksista ulkoympäristöissä

Tiivistelmä

Tämä väitöskirja käsittelee oppilaiden vuorovaikutusta ja luonnontieteiden opettamisen käytänteitä väljästi valvotuissa ulkoympäristöissä. Tutkimuksen tavoitteena on selvittää, millaisia mahdollisuuksia kaukana opettajasta työskentelevillä oppilailla on osallistua luonnontieteiden opiskeluun affektiivisesti mielekkäillä tavoilla, ja millaisin opetuksellisin järjestelyin nämä mahdollisuudet voivat toteutua. Väitöskirja pyrkii näin lisäämään ymmärrystämme siitä, miten luonnonteiden opetuksen vieraannuttavia ulottuvuuksia voidaan lieventää.

Ilman opettajan jatkuvaa valvontaa tapahtuvan opiskelun aikaisten oppilaiden kokemusten ja vuorovaikutuksen ymmärtämiseksi väitöskirjassa tutkitaan metsässä työskenteleviä oppilasryhmiä sekä opettajia, jotka toteuttavat paljon maasto-opetusta biologian opetuksessa. Tutkimuksen empiirinen aineisto koostuu oppilasryhmien videoinneista, yhteydenpitoon käytetyistä mobiiliviesteistä sekä oppilaiden ja opettajien haastatteluista. Aineiston analyysissä keskitytään oppilaiden vuorovaikutuksessa ilmeneviin sosiokulttuuriisin ilmiöihin sekä opettajien puheeseen maasto-opetuksen käytänteistä.

Väitöskirjan tulokset kuvaavat erilaisia ei-käsitteellisiä mutta kulttuurisesti tärkeitä keinoja, joiden avulla oppilaat yhdistävät luonnontieteiden oppimisen arkikokemuksiinsa sekä käsittelevät luonnontieteiden auktoritatiivisuutta. Nämä vuorovaikutuksen tavat näyttäytyvät mahdollisina keinoina lieventää opetuksen vieraannuttavia piirteitä estämättä tehtävien suorittamista. Lisäksi tutkimuksen tulokset kuvaavat, millaisilla opetuksellisilla ratkaisuilla voidaan saavuttaa tasapaino oppilaiden vapauden kokemuksen ja kontrollin välillä ja muuttaa alkujaan epätavallinen oppimisympäristö oppilaille tavalliseksi koulutyöksi.

Väitöskirjan tulokset kannustavat kasvattajia ja tutkijoita suhtautumaan kaikkiin oppilaiden luonnontieteiden tuntien aikaisiin kokemuksiin potentiaalisesti tärkeinä ja arvokkaina. Väljästi valvotut oppimistilanteet vaikuttavat mahdollistavan oppilaille affektiivisesti mielekkäitä tapoja luonnontieteiden opiskeluun sillä edellytyksellä, että tietyt kontrollia lisäävät käytänteet takaavat riittävän keskittymisen tehtäviin.

Avainsanat: etnometodologia, luonnontieteiden opetus, maasto-opetus, sosiokulttuurinen psykologia

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In Helsinki, 21st May 2020
Anttoni Kervinen

List of original articles

This thesis is based on the following articles:

I Kervinen, A., Roth, W.-M., & Juuti, K., Uitto, A. (2020). The resurgence of everyday experiences in school science learning activities. *Cultural Studies of Science Education.* doi: 10.1007/s11422-019-09968-1

II Kervinen, A., Roth, W.-M., & Juuti, K., Uitto, A. (2020). "How stupid can a person be?" – Students coping with authoritative dimensions of science lessons. *Learning, Culture and Social Interaction*. doi: 10.1016/j.lcsi.2019.100367

III Kervinen, A., Uitto, A., & Juuti, K. (2020). How fieldwork-oriented biology teachers establish formal outdoor education practices. *Journal of Biological Education* 54(2), 115-128. doi: 10.1080/00219266.2018.1546762

The original articles (Study I, Study II, Study III) are included as appendices in the printed version of this dissertation. They are reprinted by permission of the publishers.

Contents

1 Introduction

"The feast was a temporary suspension of the entire official system with all its prohibitions and hierarchic barriers. For a short time, life came out of its usual, legalized and consecrated furrows and entered the sphere of utopian freedom." (Bakhtin, 1984a, p. 89)

1.1 Out of earshot of and out of sight of the teacher

Teachers and educational researchers tend to direct their attention to the processes that they think are important for learning, but it is well known that many other things take place in typical classroom situations. Let us imagine a teacher who gives a student group a small science inquiry task that he considers to be both very instructive and motivating for them. He then turns his back to the students and walks away to another group. After a while he returns to check up on what has been done, and finds the students chattering about something completely different from what the given task requires. The teacher feels disappointed—perhaps the task had not been motivating enough to attract the students' complete attention, or perhaps the teacher has failed in communicating with the students.

We may continue by thinking of a science education researcher who is interested to learn about the students' inquiry process. She wants to study how a task supports students' understanding of science, promotes conceptual learning and increases motivational engagement. She asks the students to state during or after the task, if the task is interesting as a way in which to trace their motivational orientation (e.g. Loukomies et al., 2013). Watching the video recordings of the groups working, she seeks to select the moments of interest when the key concepts of the phenomena are being applied (e.g. Hug, Krajcik, & Marx, 2005) or where the students argue about the conclusions (Naylor, Keogh, & Downing, 2007). The moments when students talk about something that is not related to the task—like the moment before the teacher enters— she codes as "off-topic", something not to use the precious analytical effort for.

However, for the students in that group, the discussion intercepted by the teacher's arrival, for example on what happened after school the day before, is just as real and meaningful an instance of the lesson as the argumentation on the scientific concept. For some students, it might even be the most important discussion of the lesson. After all, it is what makes the most sense for a student or students to talk about at that moment. Yet,

the instances when students deviate from the task or the normative classroom order and teacher's plans tend to be studied mainly from the perspective of what went wrong. Especially during practical activities, unsuccessful classroom management on the teacher's part is considered to cause disturbances that may cause negative emotions for students (Itzek-Greulich & Vollmer, 2017).

On the other hand, students opposing the teachers is treated as a disciplinary problem and anti-academic behavior that relate to low academic achievement and low motivation (Arens, Morin, & Watermann, 2015; Phelan, Yu, & Davidson, 1994). Several studies have called for teachers to provide students with opportunities to express opinions and for their initiatives to be heard (e.g. Aguiar, Mortimer, & Scott, 2010). But studies on occasions when the teacher would not have control over the discourse are rare. Teachers tend to supervise tightly and maintain their control of the interaction even on out-of-school activities such as trips to museums or botanic gardens (DeWitt & Hohenstein, 2010; Zhai & Dillon, 2014). The fear of losing control is the main concern when organizing such activities (Glackin, 2017). What could be fun for the students often turns out to be not so much fun (Roth, van Eijck, Reis, & Hsu, 2008).

A typical lesson in a classroom may include numerous situations like the imaginary example at the beginning of this section. A study showed how a group of students may have a conversation completely without the teacher's awareness (e.g. Roth, 2009). Also, the teacher's placement in a classroom alone had great influence on how students in different spots in the classroom participate in the activities (Roth, McGinn, Woszczyna, Boutonne, 1999). There is a clear gap in educational research that concerns students' ways of utilizing the moments of temporary freedom that appear in the course of learning and during loosely supervised settings in particular. Are the "off-topic" activities merely off-topic, or could the meaningfulness that they inevitably bear for the students be turned into benefits for the learning as well?

As the quotation at the beginning from the analysis of a medieval carnival by Mikhail Bakhtin demonstrates, the times when official restrictions are put aside allow a whole new world to open and be experienced. Similarly, when students work independently and out of earshot of the teacher, moments may be emerging in which new opportunities emerge for the contents and form of student conversation, with new opportunities to connect the present experience to the learning of science content. This dissertation focuses on such moments when the teacher has their back to the students, and the initiative for engaging in science learning is given to students working on their own. This research

investigates the ways students make science learning activities affectively meaningful and relatable for themselves and how learning settings with less supervision can be implemented to support these processes. The example at the beginning of this chapter shows how much of educational research concerns things that the teacher has control over. In this dissertation, a contrary approach is taken; the focus is shifted towards how students make out of the moments when the control and supervision is decreased as the students work out of sight and out of earshot of the teacher. Taking all the students' (inter)actions as an important manifestation of their experiences during learning activities allows the understanding on how instruction can be developed into genuinely meaningful directions. In the dissertation I have taken a practical stand by providing implications for developing science teaching in loosely supervised settings, particularly in outdoor environments, where students' choice is emphasized.

1.2 Moderating students' alienation from science education: shifting perspective from instruction to students

One of the major challenges for schooling in general is that it can feel distant for students (Säljö, 2004). This is particularly so regarding science education. The alienation from science poses a serious challenge for modern societies at a time where more people are needed for work force in the field of science and technology (e.g. Sjøberg & Schreiner, 2010; Tytler, 2007). In science education, the challenge derives not only from the unrelatable formal education system but also from the characteristics of science itself. Science often represents a space apart from the world students are familiar with (e.g. Barmby, Kind, & Jones, 2008; Moje et al., 2004). Scientists understand that science is a process rather than a product, and its power derives from the rationality, openness, and reasoning instead of rigidity (Latour, 1987). Yet, many practices of science education tend to manifest an authoritative, undisputed and a serious side of the sciences through their emphasis on the transmission and reproduction of canonical knowledge (Barton, 2009; Sharma & Anderson, 2009). In addition, the lack of opportunities for students to draw from their everyday experiences and ideas and to use their own voices in science lessons has been linked to disengagement in science learning and to a decrease in motivation and academic performance (e.g. Aguiar et al., 2010; Fredricks, Hofkens, Wang, Mortenson, & Scott, 2018; Morales-Doyle, 2018; Lyons, 2006).

Partly to meet these challenges, current teaching practices in science education emphasize students' active participation in scientific practices. Students should learn to ask questions, draw on their own experiences,

critically evaluate information and apply their knowledge in various everyday settings (Crawford, 2014). There are calls for more dialogical approaches and forms of classroom interaction that provide students with opportunities to express their opinions and understandings and thereby increase engagement in learning tasks (Hsu & Roth, 2014; Lehesvuori, Viiri, Rasku-Puttonen, Moate, & Helaakoski, 2013). A central argument for increasing activating and autonomous practices derives from the affective benefits they have for the students; for example, students' opportunities to make choices during laboratory activities has been shown to increase engagement (Schmidt, Rosenberg, & Beymer, 2018). Attempts to make education more engaging are not limited to classrooms. It has been suggested that activities expanding outside the classroom are especially helpful for connecting schoolwork with the changing society and enhancing attitudes about school learning (Rajala, Kumpulainen, Hilppö, Paananen, & Lipponen, 2016; Resnick, 1987). In science education, it is considered that field trips to science centers, museums and to nature sites provide authentic opportunities to engage with scientific phenomena (Rennie, 2014). Not only do the trips outside the classroom provide authentic opportunities for science learning activities, but the out-of-school environments provide opportunities for increased dialogical interaction between the students and the teacher (DeWitt & Hohnstein, 2010). There is also evidence that during the out-of-school activities, the autonomy-supportive forms of guidance are most beneficial to students' motivation (Basten, Meyer, Ahrens, Fries, & Wilde, 2014; Tal, Lavie Alon, & Morag, 2014), whereas the mere fieldtrip experiences are not necessarily followed by positive emotions in students (Roth et al., 2008).

The emphasis on students' active role in making choices and taking initiatives also poses challenges for teaching and interaction in classrooms. Typically, in the classrooms, students are required to "appropriately engage in classroom interaction from the point of view of the teacher" (Mehan, 1979; p. 124), and the teacher has the power to impose various sanctions when these requirements are not met. The need for control is understandable as it relates to the power of the teacher that is ingrained in the institutionalized schooling (Gore, 1995). Moreover, good classroom management can prevent disturbances and misbehavior and result in motivating atmosphere and smoothly orchestrated activities (Steffensky, Gold, Holdynski, & Möller, 2015). The need for classroom management and the calls for increasing dialogues, choices and freedom appear to be contradictory. The more students are granted freedom for and encouraged to make choices, mutual interaction in inquiries and ask questions, the less the teacher can dictate how the interaction during the learning activities

unfolds. For example, students' unexpected questions and initiatives may create a tension between the teacher's demands even if the teacher seeks to foster dialogical interaction (Aguiar et al., 2010; Scott, Mortimer, & Aguiar, 2006).

Teachers face challenging situations regarding less supervised learning settings. Increasing the amount of freedom for students to affect the course of the interaction is contradictory to the teachers' apparent need for control. Educators can design learning activities that support the aims of authentic and engaging science learning, and a great number of studies have investigated the effects of these approaches. But whereas these studies provide valuable information on how to support students' engagement and make science learning meaningful, the role of the students tends to be perceived in relation to the goals and reactions intended by the educators. As reviewed above, students' opportunities to make choices, pose questions and critique and draw from their everyday lives are all important to make science learning relatable and authentic. Yet, if something that appears meaningful for students diverges from the goals and context of the lesson—for instance students talk of their everyday life or make jokes—it easily ends up being perceived as being "off the topic" and excluded from both the lesson and research. Nonetheless, students experience the learning situations and relate to science learning successfully from the fullness of their everyday life, with often considerably different thoughts and interests than intended by the teacher (Roth, 2009). Little research has been undertaken about students' ways to make learning situations affectively meaningful as the need for this arises during science lessons.

With this dissertation the focus of making science learning meaningful is shifted from what the educators may do to what the students can make use of themselves. The research focuses on the moments when the decreased amount of control and supervision, deriving from the physical absence of the teacher, allows the initiatives to make science learning affectively meaningful and relatable come from the students. Affective meaningfulness here refers to emotional, attitudinal and motivational elements related to learning in a broad sense in distinction to rationalized and conceptual appraisals of learning or its meaning. Being and interacting in the world is affective through and through, as every idea also contains an affective attitude that can be traced to a person's needs and impulses (Vygotsky, 1986). Yet, when assessing learning outcomes or a student's relationship with their schools, affective and cognitive factors are often separated (e.g. Hascher & Hadjar, 2018; Rodríquez, Plax, & Kearney, 1996). Therefore, I have used *affectively meaningful* to emphasize that the focus here is not on the cognitive learning outcomes or the conceptual reasoning

of the meaning of learning but on the affective premises of experiencing the learning situations. In this dissertation, various aspects of students' interaction are identified and theorized as ways to make learning situations more relatable, manageable and meaningful within the affective (and bodily) premises of being and, thus, within the fullness of life through which the cognitive processes are also shaped.

Following the calls for increasing students' engagement and addressing alienation from science learning, the dissertation aims at increasing understanding on the variety of affectively and culturally feasible ways for students to participate in doing and learning science. The main objective is to investigate how these opportunities arise in loosely supervised settings when working out of earshot and out of sight of the teacher. By investigating interactions between students who work in an instructional setting with less supervision compared to typical classrooms and instructional strategies that render these settings possible within formal education, the aim in the dissertation is to provide implications for developing science education in directions that help to moderate students' alienation from learning science.

2 Theoretical background

Theoretically, in this research I have explored the variety of sociocultural and affective ways that expand beyond the cognitive-conceptual understanding in which students connect science learning with their everyday lives and participate in dialogic interaction with one another and the teacher (Studies I-II). This chapter begins with a short introduction to the essential aspects of socio-cultural theory to frame the studies on students' interaction and affect during science learning. Then, theoretical aspects related to Mikhail Bakhtin's work as well as phenomenological philosophy are addressed. These perspectives present the main framework for analyzing the students' ways of relating to science learning and how these ways expand beyond cognitive dimensions. Finally, the use of outdoor learning environments and characteristics of institutionalized education processes are discussed to a contextualize the present research in the possibilities of everyday formal schooling (Study III).

2.1 The sociocultural take on the *fullness of life*

In this study, students were observed in loosely supervised and controlled field settings in which they were able to move and interact relatively freely and talk about a range of things related to the tasks they had. To understand the processes of learning and doing science as they appear for the students as part of their holistic experiences, a sociocultural approach must be taken. The question about the nature of learning itself is a persistent topic in educational psychology. Traditional individualistic theories draw from the Piagetian constructivism and individual information processing, making a clear distinction between the individual learner and the environment. Educational research from this perspective takes the individual, mental processes as the unit of analysis and focuses on conceptions, beliefs, emotions and mental frameworks. Individualistic approaches, however, are too limited for understanding the comprehensive characteristics of knowing and learning. Russian psychologist Lev S. Vygotsky (1934/1987) criticized the "atomistic and functional form of analysis [that] treated the psychic processes in isolation" (p. 1) as inadequate way to understand human development and learning. Vygotsky's work on the interactional nature of human activity laid foundations on sociocultural and cultural-historical theories of educational psychology that take account of learning as a collective process of interacting individuals and their environment,

something that is not reducible to the mental processes of a particular individual. Instead of considering students as individuals who acquire inputs from the outside and construct knowledge through certain mental processes, the sociocultural approach locates learning and knowledge in the process of social activity.

The central difference between the constructivist theories of learning and sociocultural ones is the shift of the unit of analysis from the individual to the collective. This shift not only allows learning to be studied as a socially shared cultural phenomenon; it also requires expanding the scope of educational research from what students learn from a certain way of teaching to asking how the actual learning processes unfold. In the field of science education, the sociocultural framework has been increasingly applied to examine the link between language and learning in interactional settings such as the classroom discourse (e.g. Aquiar et al., 2010; Gilbert & Yerrick, 2001; Levrini, Levin, Fantini, & Tasquier, 2019; Lidar, Almqvist, & Östman, 2009).

Sociocultural frameworks locate learning in the dialectical unit of activity that includes all the participants as well as their cultural historical background and affective experiences (Roth & Lee, 2007). Therefore, the sociocultural framework informs current research theoretically and methodologically in two particular ways. First, the processes of doing (and learning) science are analyzed as social phenomena, as they unfold in the communication and interactions between the students. This means that the analysis focuses the interactions that the participants make available and visible to each other and instead of requiring any special interpretive methods of knowing what happens inside their minds. The role of interaction and language-mediated communication is discussed more as an analytical framework for the analyses later. Second, it is acknowledged and emphasized that the students' interaction and experiences in the learning situation fundamentally integrate practical and affective dimensions of life —including emotions and attitudes— and how these are connected to their everyday experiences. Vygotsky (1934/1987) problematizes the separation of intellect and affect as subjects of study when analyzing the interrelations between thought and language, considering it as "a major weakness of traditional psychology, since it makes the thought process appear as autonomous flow of 'thought thinking themselves,' segregated from the fullness of life, from the personal needs and interests, the inclinations and impulses, of the thinker" (1934/1987, p. 10). What is important and meaningful in the learning processes for students should be of interest to educators and researchers as well; and the focus of research therefore needs to include the full spectrum of life that students experience.

There are calls for science education to account for the fullness of life of the students during learning better (Roth, 2009). Indeed, learning in classrooms does not take place in a vacuum. It is a common observation of teachers that the cognitive and social focus of students is not always directed solely at what the teacher has planned. There are moments when the important things in life seem to be different from the things one should be concentrated on at a given moment; and various skills of self-regulation are required to be learned (Zimmerman, 1990). Affect, in the form of emotions, attitudes and motivation, is considered to direct learning processes and their effectiveness significantly (Huang, 2011). When learning expands beyond the formal school context, students can more easily make connections with the everyday world and academic learning (Resnick, 1987).

Yet, studies on learning situations tend to exclude what does not apparently relate to the conceptual content or the cognitive process of learning. What does not seem to relate to conceptual learning is usually classified as off-topic activity and simply left out of the analyses (Roth, 2009). Alternatively, what students discuss or do outside the topic at hand is not considered to belong in the actual learning process and can be treated as a sign of low concentration and motivation (Arens et al., 2015; Phelan et al., 1994); or the behavior of students who do not comply with the norms of formal classroom order are explained as the cultural gap between (marginalized) children and the official school (Brown, 2004), and the implications are treated in terms of misbehavior, disciplinary problems and deviated classroom order (Itzek-Greulich & Vollmer, 2017; Steffensky et al., 2015).

While achieving the conceptual goals of teaching and learning requires concentration and often disciplinary efforts from the teacher, the nature of any learning situation for a student is far more complex. This is so because students' experiences in any learning situation—and how they relate to the everyday life—expand beyond solely the conceptual and cognitive dimension, fundamentally integrating practical and affective dimensions of life (Roth & Jornet, 2014). The ways in which this fullness of life, postulated by Vygotsky (1934/1987) through personal experience, is linked to the learning processes of students during a learning task, are at the focus of the current research. The things that might be considered as "off-topic" because they do not relate to the cognitive-conceptual goals, are here treated as equally included in students' experiences of their life at the moment as the "topic" itself. Thus, instead of considering distraction from the task as merely a distraction, the present research explores the ways doing science tasks and being distracted from them can merge in students'

interactions. The two are not perceived as alternatives for each other but as components of a student's current experience. Because the whole experience is meaningful for the student, the potential for accessing science learning in meaningful ways also resides in that experience.

In particular, the aim of this research is to explore the variety of ways beyond the intellectual, conceptual understanding in which students connect science learning with their everyday life as well as deal with the authoritative and potentially suppressive dimensions of science teaching, and how both can enhance meaningful learning. The theoretical foundations of these aims are mainly drawn from two particular areas of sociocultural perspective: (a) Mikhail Bakhtin's work on the dialogical and carnival nature of social life and (b) phenomenological approach that emphasizes the preliminary affective and bodily experience as the premise of understanding the world. In the next two sections, these two frameworks are introduced in more detail. How the sociocultural standpoint informs the methodological and analytical approach of this study is further described in Chapter 4.4.

2.2 Dialogism and Bakhtin's carnival principal in science learning

2.2.1 Dialogical interactions moderating authoritativeness in education

For scientists, science and scientific knowledge is an open and rational process of reasoning rather than a static product (Latour, 1987). Indeed, scientists understand science as socially constructed (Gilbert & Mulkay, 1984). Yet, scientific knowledge unquestionably has an objective and undisputed dimension in explaining the observed world once the debates have settled. For example, the theory of gravity is taken as granted when engineering buildings, not that much as an excellent approximation of observable reality. Because of this settled and undisputed dimension of scientific knowledge "the exact sciences constitute a monologic form of knowledge" (Bakhtin, 1986, p. 161), which leads to their authoritative nature that does not tolerate alternative forms of knowing (Bakhtin, 1984b). It is thus not surprising that for the larger public, scientific knowledge tends to have an uncontested nature and scientists are treated as authoritative sources of information without acknowledging the argumentative nature of science (Barton, 2009; Ford & Wargo, 2012; Kolstø, 2001).

Science educators are indeed facing a challenge here: how to reproduce the sciences by transmitting current scientific knowledge while enforcing

the understanding of scientific knowledge as a progressive and changing process that is based on evidence and arguments? The recent decades have brought yet another challenge—the students' declining interest and alienation from science education (Barmby et al., 2008; Osborne, Simon, & Collins, 2003). The difficulty to maintain interest in science learning has been partly attributed to students' everyday experiences and perceptions of their life as being so different from the authoritative truth of science that they become alienated and feel like outsiders in science education (Lyons, 2006; Roth, 2009). To meet the above described challenges, several pieces of science education research have focused on how science can be presented in dialogical ways that allow for a multiplicity of voices and arguments—including the ones of students—to be present in science classes (e.g. Aguiar et al., 2010; Lehesvuori et al., 2013).

The dialogical principle is based on the work of philosopher and literary critic Mikhail Bakhtin (1984b, 1986), who analyzed the polyphonic and unfinalizable nature of dialogues in Fyodor Dostoyevsky's books. According to Bakhtin, the dialogue between two people does not guarantee the dialogical nature of the discourse. This is so because even though there may be two or more participants in a verbal exchange, the encounter can be monologic when the truth of the outcome is pre-established—such as in the late period of Plato's Socratic dialogues (Bakhtin, 1984b). The same applies to the classroom discourses. Thus, the essential goal of dialogical teaching is to make students' initiatives influential and important in the classroom discourse instead of being merely replies to the authoritative teachers' queries or items for evaluative purposes (Aguiar et al., 2010). This is not an easy task for a science educator to achieve. As already mentioned, the nature of scientific knowledge itself has an authoritative dimension (e.g. Kolstø, 2001). Too often, this authoritativeness is reproduced in the reliance on scientific inscriptions and textbooks on which teachers as well as students much rely (Goldston & Kyzer, 2009; Kesidou & Roseman, 2002; Lee & Kim, 2014). Even the teachers have epistemological beliefs of scientific knowledge as authoritative and unquestionable (Smith & Anderson, 1999), and the controversial and uncertain aspects of science are often excluded from the teaching (Ford & Wargo, 2012). Grading practices are central to institutional education but are suggested to have an authoritative function as they hamper the realization of the dialogical science discourse, easily subdue students' individual voices and increase the distance from everyday lives (Roth & McGinn, 1998; Sharma & Anderson, 2009).

Most studies on the dialogical goals of learning focus on the classroom discourse and how the teacher's choices affect the quality of the interaction

(e.g. Aguiar et al., 2010; Lehesvuori, et al., 2013). This is a natural and important line of research, as the teacher alone usually has great influence on the interactional setting of the classroom (Mehan, 1979). For example, studies show that negative affect (in the form of emotions) can arise in situations in which students face evaluative feedback from the teacher or have difficulties finding the right scientific answer or the correct way to proceed with the given task (Bellocchi, 2018; Bellocchi & Ritchie, 2015; Brown & Melear, 2006). However, the possible interactions of a dialogical nature that arise among the students without visible effort from the teacher's side, remain largely unexplored. Whereas the negative consequences of authoritative science teaching have led to the promotion of student-centered teaching methods and dialogical approaches (e.g. DeWitt & Hohenstein, 2010; Fredricks et al., 2018), very little research exists about how students are coping with the authoritative dimensions and their possibly negative affective tones *as they arise* in science lessons. As noted above, many lessons include moments when students have discussions that the teacher remains unaware of—not to speak of the interactions that arise outside the classroom when the teacher is out of earshot and out of sight.

This research investigates the multitude of ways in which students might overturn the authoritativeness and actually cope with the potentially negative or suppressing emotions that follow. For this purpose, a case from outdoor science teaching is taken (Study II), when the teacher is not physically present most of the time but communicates with students though mobile messages. This allows the mutual interaction among the students and the means of dealing with the authoritativeness to become particularly visible, thereby enabling them to be studied.

2.2.2 Carnival sense of life and science education

Taking account of the momentary freedom that the teacher's physical absence enables for the students, another area of Bakhtin's work becomes fruitful in the analysis of students' interactions. Bakhtin's (1984a) analysis of the books written by the French author François Rabelais describes people's relationship with the authoritative structures of the medieval society, and accordingly their ways to oppose and resist the seriousness of the institutional powers. In his analysis, Bakhtin showed how particularly the times of feast and carnival gave ordinary people "a temporary suspension of the entire official system with all its prohibitions and hierarchic barriers. For a short time, life came out of its usual, legalized and consecrated furrows and entered the sphere of utopian freedom" (Bakhtin,

1984b, p. 89). Paralleling the extraordinary nature that the feast and carnival had in the lives of medieval people, the outdoor lessons in this dissertation were of an extraordinary nature for students compared to typical classroom settings; students could freely move around on their own, interact without too many restrictions and make choices about what to do without the teacher being able to directly interfere. Even if the outdoor work was part of formal education—not a carnival per se—Bakhtin's work provides a valuable lens for exploring what happens when the teacher not only turns her back but is even hundreds of meters away.

For Bakhtin, the *carnival* refers eventually to the *carnival principle* rather than the particular time of feast. It is a metaphor of a cultural phenomenon that is characterized by "emphatic and purposeful "heteroglossia" *(raznogolosost's)* and its multiplicity of styles *(mnogostil'nost')*. Thus, the carnival principle corresponds to and is indeed a part of the novelistic principle itself" (Bakhtin, 1984a, p. x). The carnival comes close to what was considered as the principle dialogism and acknowledging of the simultaneity of multiple voices and perspectives. But whereas both concepts of dialogism and carnival principle share the analytical sensitivity for acknowledging multiple simultaneous perspectives in a cultural (dialogical) form of interaction, the *carnival sense of life* foregrounds the asymmetric relationship between the people and its authoritative institutions.

The carnivals allowed for people to make fun of, ridicule and mock—accompanied with swears and oaths—the ruling order of the society. The carnivals were legalized by the authorities—not only were they allowed and made possible but also arranged by the authorities. Indeed, nowhere else in the medieval society was it possible to *publicly* ridicule and abuse the church or king without the fear of punishment. Yet, the nature of carnival freedom—even in its occasional vulgarity—was affable rather than serious or hostile. Primarily it was a means for people to experience and express a meaningful distinction from the authoritative institutions and themselves, as the carnival laughter "builds its own world in opposition to the official world, its own church versus the official church, its own state versus the official state" (Bakhtin, 1984a, p. 88). The carnival principle prepares the way to what Bakhtin described grotesque realism and the material bodily principle. The carnival laugher, vulgar jokes and abusive language share the same bodily background; "[t]he essential principle of grotesque realism is degradation, that is, the lowering of all that is high, spiritual, ideal, abstract; it is a transfer to the material level, to the sphere of earth and body in their indissoluble unity" (Bakhtin, 1984a, p. 19-20). Grotesque realism manifested in the bodily (lower stratum) oaths and jokes

of the carnival and in the swearing enriching the chatter in the marketplaces. Again, within the carnival spirit, this "marketplace speech and gesture, frank and free, permitting no distance between those who came in contact with each other and liberating from norms of etiquette and decency imposed at other times" (Bakhtin, 1984a, 10).

Whereas Rabelais' books concerned medieval culture, Bakhtin notes that the authoritativeness of the institutional order is not bound to history: "Rationalism and classicism clearly reflect the fundamental traits of the new official culture; it differed from the ecclesiastic feudal culture but was also authoritarian and serious, though less dogmatic" (p. 101). Thus, the carnival sense in life is not bound to a historical time, even if the medieval carnivals per se had their special characteristics. Whereas medieval carnivals and feasts momentarily overturned the power of church and king, the authoritative dimensions of science represent the official truth and rational seriousness of modern culture. The carnival sense of life, respectively, can be reflected in the cultural forms of entertainment and humor that ridicule and question the rationality and the seriousness any modern institutional order and truth. Indeed, a "vague memory of past carnival liberties and carnival truth still slumbers in these modern forms of abuse" (Bakhtin, 1984a, p. 28), and also the people in the modern world seem to find need to establish their "own worlds in opposition to the official world" (Bakhtin, 1984a, p. 88) or "a second life, a second world of folk culture" (p. 11). The liberating carnival laughter of modern world may be heard for example in many forms of (popular) cultural activities such as digital games, allowing a temporarily escape from official truth and its seriousness (Calleja, 2010; Storey, 2018).

As a legitimized opportunity for disparaging the official order, the carnivals (and the carnival principle) had one fundamental characteristic that was their temporality. The carnival was supposed to be and perceived primarily as a "*temporary* liberation from the prevailing truth and from the established order" (Bakhtin, 1984a, p. 10, emphasis added). The temporality of the carnival had essential implications. The fact that the feast and the carnival were permitted to occur only momentarily and at a fixed time meant that after the carnival was over, the institutional order with hierarchies and prohibitions was also back. Indeed, the temporality signified that the "legalization was forced, incomplete, led to struggles and new prohibitions" (p. 90). Whereas the participation in the feast would mean a temporary entrance to the sphere of utopian freedom, it is not a far-fetched argument that from the viewpoint of the ruling class, the carnival served as a safety valve for the passions of the common people that might otherwise be directed in a more harmful manner (Bakhtin, 1984a, xviii).

Like the carnival reversing the prohibitions and seriousness of life, the paralleling has been shown in a study on how humor and laughter—analogically to the Bakhtinian sense of carnival—reverse the seriousness of science (learning) (Roth, Ritchie, Hudson, & Mergard, 2011). Moreover, the authors showed how the reversal was only momentary; it actually led to the emphasis on the seriousness of science afterwards and, like carnival, thus worked as a double-reversal. At the same time as humor and laughter undermined the serious and single voicedness of science, they supported the enactment of science by reproducing positive emotions in both students and teachers.

The carnival sense of life fundamentally involves the affective dimension of relating to the world around us. As discussed earlier, the research of science education too often fails to recognize the fullness of life—with its affective and bodily dimensions—as the relevant unit of analysis of educational interaction. Affect—in the form of emotions, humor and imagination—is inherent also in the world of science and scientific progress (Berge, 2017). Humor and laughter are inherent parts of scientific activities (Lynch, 1985). Bakhtin (1984a, p. 49) notes that "the principle of laughter and the carnival spirit on which grotesque is based destroys this limited seriousness and all pretense of an extratemporal meaning and unconditional value of necessity. It frees human consciousness, thought, and imagination for new potentialities. For this reason, great changes, even in the field of science, are always preceded by a certain carnival consciousness that prepares the way."

Yet, in the context of science education, humor and laughter are rarely focused on as an interactional resource. One study showed that when laughter is not perceived as an alien phenomenon to science lessons (Roth et al., 2011) but—in a carnival sense—is shown as an integral part of people's ways of coping with the world, proof can be found of how it supports student's enactment of science by reproducing and transforming positive emotions. Other educational studies have investigated how the moments of carnival can arise during students' interaction in classrooms, providing students with access to alternative truths and ways of speaking to the ones proposed by the teacher's and academic aims (Blackledge & Creese, 2009; DaSilva Iddings & McCafferty, 2007). In the above-mentioned studies, the carnival sense arises with no apparent stimulus among the students or is initiated by the teacher. On the contrary, this research focuses the carnival sense in how students actively make connections with their affectively meaningful everyday resources and doing (learning) science, especially at times when science learning appears to be distant or authoritative. Drawing from the outdoor science activities

in which the students are on their own, the present research investigates resurgence of students' everyday experiences and their ways of coping with the perceived authoritative dimensions of teaching.

2.3 The experiential and common-sense foundation of knowledge

Bakhtin's carnival principle provides an analytical tool for understanding how humor, laughter and the bodily and grotesque dimensions of life can be represented in and shape educational interaction in affectively meaningful ways as integral parts of the fullness of students' lives. However, as briefly discussed previously, science learning and education expand beyond the cognitive and conceptual understanding also in other areas that are inherent in our everyday experiences. In fact, the origin of empirical sciences is far from purely a conceptual matter. Our way of understanding the material world is fundamentally grounded on our ability to observe our environment and make conclusions and eventually different forms of abstractions from these observations. Drawing from phenomenological and pragmatist theories of understanding the surrounding world, the bodily and affective experience of the world can be considered as the perquisite for any conceptual knowing (Husserl, 1989; James, 1907)

Some philosophers underline the intuitive and self-evident facts of the lived-in world as the foundation on which the understanding of the world relies (e.g. Husserl, 1989; James, 1907). It is the experiential understanding that forms the primal premises of knowledge on the world; thus, also the origin of the sciences can be traced back to the primal premises of meaning that "lie in the prescientific cultural world" (Husserl, 1989, p. 172). Accordingly, "in every individual life from childhood up to maturity, the originally intuitive life which creates its originally self-evident structures through activities on the basis of sense-experience very quickly and in increasing measure falls victim to the *seduction of language*" (p. 165). On these primary and fundamental evidence from sense-experience, which is the foundation of common sense, the subsequent understandings are layered. The cultural present therefore "implies a continuity of [cultural] pasts which imply one another, each in itself being a past cultural present" (p. 173). And although new scientific knowledge occasionally undoes the earlier forms of understanding, the very foundation of first and primary experiential premises of understanding remain its foundation.

Husserl's way of thinking about the experienced world shares a similarity with James (1907), who suggested that the fundamental ways of

our thinking are based on a commonsense level of thought. Whereas Husserl underlines that scientific idealizations must have "apodictically general content, invariant throughout all conceivable variation" (Husserl, 1989, p. 179) for them to be culturally passed on, the common sense described by James is grounded in sense-impressions that become rationalized by a set of concepts such as "thing," "the same or different," "subjects and attributes," and "causal influences" (James, 1907, p. 173). These common-sense categories and the vast expanse of associated, generally invisible common sense become the foundation of our understanding of how the world works and the linguistic conceptualization of it. This is so because these conceptualizations "have been verified by the immediate facts of experience which they first fitted; and then from fact to fact and from man to man they may have spread, until all language rested on them and we are now incapable of thinking naturally in any other terms" (p. 182–183). Common-sense levels of thought may be separated from the scientific level of thought when science extrapolates to "invisible impalpable things; and the old visible common-sense things are supposed to result from the mixture of these invisibles" (p. 185). But the fundamental role of commonsense in our practical understanding of how the world works remains.

Both Husserl and James trace the scientific understanding of the world, as abstract as it may be, back to these experiential premises. An origin of any scientifically conceptualized phenomenon is an individual experience in the world of everyday life that historically and progressively transforms its meaning to a more conceptual or abstract form. That the originally intuitive life quickly "falls victim to the *seduction of language*" (Husserl, 1989, p. 165) does not mean that abstractions of the experienced world would be futile on unnecessary. However, it is necessary to consider the invariant aspect of the scientific content— rooted in the very first sense-experiences of the world—for its meaning to be handed down and reproduced by the next generations. Otherwise, the meaning of the knowledge and the thinking activity remain "bound to what is merely factual about his present or something valid for him as a merely factual tradition [...] understandable only by those men who shared the same merely factual presuppositions of understanding" (Husserl, 1989, p. 179).

The fundamental importance of acknowledging the primary premises of scientific knowledge for it to be genuinely passed on in an educational context appears to be a requirement for providing access to these experiential premises (Juuti, 2014; Roth, 2014). As the experiential premise constitutes the foundation behind the logic of a given phenomenon and concept, learners of new epochs re-live the conceptual idealizations that

historically led to the first scientific idealizations (Husserl, 1989). Otherwise, science would merely be logical and have no more connection to the world that makes sense from the beginning. For science education to build on these experiential premises, a genetic approach has been suggested, emphasizing the primary experiential observations as the starting point of learning and the counterintuitive world of science continuing to be based on them (Roth, 2014). The sentences in which the scientific discipline is expressed "must be fixed and capable of being made self-evident again and again" (Husserl, 1989, p. 177).

The emphasis on the experiential premises is characterized by the foundational role of the bodily interactions in (scientifically) understanding the world. However, the bodily character should be conceived in a broader sense than mere physical interaction to include the shared cultural dimensions. Whereas Husserl places the experiential premises of humans in the world of things that has to have bodily character, he yet acknowledges that "not all things could be mere bodies, since the necessarily coexisting human beings are not thinkable as mere bodies and, like even the cultural objects which belong with them structurally, are not exhausted in corporeal being" (1989, p. 177). Respectively, common sense grounds in the general notion of "'[s]elf,' 'body,' in the substantial or metaphysical sense—no one escapes subjection to those forms of thought" (James, 1907, p. 180). All in all, bodily understandings are significant in students' conceptual understanding of science and grounding learning to their personal experiences (Roth & Jornet, 2016). Whereas Bakhtin's (1984a) carnival principle examines the bodily aspect interaction with the world culturally through grotesque realism and the material bodily principle—present in the marketplace speak and in carnival humor—the phenomenological and pragmatic approaches of Husserl and James extend the scope of non-conceptual understandings to include bodily aspects; they are pivotal also in cognitive—not only affective—dimension of learning sciences.

The preceding shows how the premises of the cognitive understanding of the world lie in bodily-affective experiences; these premises form the commonsense and cultural foundation for learning. Yet, most studies on how students draw on their everyday experiences or express affect take as their starting points the cognitive and conceptual dimensions of science. For example, a number of studies have investigated how students connect the conceptual content of their everyday experiences in ways that support (or do not support) science learning (e.g. Lidar et al., 2009; McClain & Zimmerman, 2014; Na & Song, 2014; Tsurusaki, Calabrese Barton, Tan, Koch, & Contento, 2012). Furthermore, even though various cultural

resources have been recognized as being used in learning situations (e.g. Avraamidou & Osborne, 2009; Moje et al., 2004), few studies have investigated the spontaneous and ongoing processes by which a student's everyday ways of understanding the world become the basis of doing and learning science.

The primacy of the non-conceptual forms of being in the world by investigating students' ways to spontaneously connect doing science with their everyday experiences and the understandings that go with these are addressed in this dissertation. A variety of cultural recourses available to students are explored to show how they may function in a resurgence of students' everyday experiences and allow the meaningful participation in doing and learning science. Along with the work of Bakhtin, and other scholars introduced in the articles (Study I and Study II), the theoretical framings presented above are used to extend the research of science learning to include the affective, non-conceptual experiences of the students—or what Vygotsky (1934/1987) called "the fullness of life" of the thinker.

2.4 Outdoor learning as an opportunity to do and learn science in less supervised ways

The focus in this dissertation is on the experiences and learning that occurs while students investigate phenomena outdoors, where they spend much of the time out of earshot and out of sight of the teacher. Instead of addressing the intended (often conceptual) goals and the instructional strategies so often placed in the focus of science education research, the present research investigates interactions that are initiated and sustained by the students (Studies I-II). The context of loosely supervised outdoor learning and the relatively free interaction among the students allows several phenomena to become particularly visible that might not be possible in the normal order of classroom teaching. However, the context of outdoor learning also allows and requires consideration of the ways by which students might be given opportunities for freedom that would not hamper goals of conceptual learning. To bring the findings back to the institutional demands and practices of teaching and schooling, this research investigates how the relative freedom of the students during the loosely controlled outdoor learning activities can be enabled from the perspective of the teachers (Study III). In this respect, outdoor teaching practices—as a relevant part of authentic science education—have been investigated from the perspective of how they can be institutionalized as a normal part of formal teaching.

2.4.1 Use of outdoor environments in science education

Activities that take place outside the classroom are important opportunities for students to connect the schoolwork with their experiences from life outside the school (Resnick, 1987). For students, all their past experiences are always present and make them who they are. Sometimes past experiences can be reactualized in the current experiences through situated and joint action, which is manifested as remembering things and drawing connections between different situations (Lidar et al., 2010). In this regard, authentic settings for science learning are where students can interact with science knowledge and tasks that bear importance in everyday lives, as well as have control and authority over these situations (Roth et al., 2008). Many attempts to develop meaningful and engaging science learning include learning outside the classroom, such as by visiting museums or nature sites (Rennie, 2014). Particularly in biology education, outdoor environments are considered to be an authentic learning setting for a range of topics, especially the structure and function of ecosystems (Braund & Reiss, 2006). In a large-scale survey studying Finnish lower secondary school students' out-of-school experiences, various activities relating to nature were found to correlate with their interest in many topics of science education, especially in biology (Uitto, Juuti, Lavonen, & Meisalo, 2006). Learning in outdoor environments have several potential benefits both cognitively and affectively (Drissner, Haase, & Hille, 2010; Rickinson et al., 2004; Randler, Ilg, & Kern, 2005), and several countries aim to include or increase the use of the outdoors as a learning environment at a curricular level (Department for Education and Skills, 2006; FNBE, 2016).

Despite its educational potential and curricular incentives, there is concern about the relatively little use of fieldwork and field trips in schools (Lloyd, Neilson, King, & Dyball, 2012; Lock, 2010; Uitto & Kärnä, 2014). Nature outings within formal science education tend to be scarce and remain primarily "add-ons" to the ordinary teaching (Lloyd et al., 2012). Organizing outdoor education seems to be challenging for several reasons of which some are related to the school culture and community (Hovardas, 2016; Scott, Boyd, Scott, & Colquhoun, 2015). Yet, many of the challenges concern the teacher's perceptions. Studies have shown that teachers experience a lack of skills and the confidence needed to use outdoor environments for science activities (Bentsen, Jensen, Mygind, & Randrup, 2010; Scott et al., 2015). Teachers fear losing control (Glackin, 2017) and try to avoid student risk (Connolly & Haughton, 2015). It is therefore not surprising that teachers' and outdoor educators' use of natural environments tend to be primarily structured and teacher led (Lavie Alon & Tal, 2017; Rajala & Akkerman, 2019). The same seems to apply to other

out-of-school locations like museums or botanic gardens, where the opportunity for dialogical interaction might increase, but the teacher or the educator is still in control of the interaction (DeWitt & Hohnstein, 2010), and the discourse is likely to be directed into authoritative direction (Zhai & Dillon, 2014). What could be fun and for the students often turns out not to be so much fun when the students lack authority and control over the situations on fieldtrips meant to be authentic (Roth et al., 2008). On the contrary, less structured activities and more free choice time during outdoor learning can promote learning and positive attitudes (Tal et al., 2014). Indeed, "the power of outdoor learning may also lie in the informality and deeply contextual learning activities engaged in, approaches to learning that traditional schooling struggles to do well" (Rea, 2008, p. 43).

In all, for outdoor settings to provide truly authentic learning opportunities appears to be a more difficult task for educators than merely taking students on fieldtrips. Many studies have described the obstacles that prevent teachers from using outdoor teaching and the challenges related to it (e.g. Bentsen et al., 2010; Glackin, 2017; Lock, 2010; Scott et al., 2015). However, studies in which the successful practices of formal outdoor teaching have been analyzed are few. This research focuses on outdoor education settings in which students' relative freedom and authority of their own are highlighted as they work without direct supervision of the teacher. Besides investigating this setting in terms of the opportunities it provides to the students, the purpose of this research is to investigate teachers' opportunities to balance control and freedom as they are manifested in instructional practices. Here, the dissertation addresses the gap in the existing research on how the authentic learning settings that require loosening of control can be implemented within formal science education.

2.4.2 The process of institutionalizing outdoor teaching practices

Many teachers find teaching outdoors difficult because they fear losing control (e.g. Glackin, 2017). In the cases of this research, after a while, the students get into the habbit of working well even without the teacher's direct presence and supervision. In this dissertation, I have investigated how the instructional practices and teachers' choices contribute to this end and enable the loosely supervised learning setting to be implemented. The framework presented by Berger and Luckman (1966) about the process and mechanism of institutionalization have been used here to investigate how the initially uncommon outdoor teaching practices are institutionalized as ordinary schoolwork for the students.

Berger and Luckmann (1966) describe the formations of institutional structures as a cognitive and interactional process that takes place between individuals. The process of institutionalization of any activity begins with habitualizing, whereby the activity can be performed repeatedly with the same effort and starts to appear as a predictable pattern for the performer. Habitualization reduces the psychological gain needed for the activity and makes room for deliberate decisions and innovations. According to Berger and Luckmann, any such habitualization turns into an institutionalized practice whenever the actions are reciprocally typificated by all actors concerned. Through the typification, the habitualized actions become institutions available to all members of the social group in question.

An important phase in institutionalization is the one in which the institutionalized activities are passed on to others who were not originally involved in the institution. Only at this point, state Berger and Luckmann, is an institution perceived and become a shared reality for the actors. Analogous to the reality of the natural world, the social formations of the institution then confront the individuals as external and coercive facts. For the established institutional order to be transmitted to the new generation, a process of legitimation needs to take place. Because the original institutional order has no subjective relevance for the new generation, there must be "explanations and justifications of the salient elements of the institutional tradition" (Berger & Luckmann, 1966, p. 111). According to Berger and Luckmann, legitimation includes both cognitive and normative aspects: a justification of the values of an institutional tradition must be preceded by an explanation of the reasons why an individual performs or does not perform a certain action. Through legitimation, the institutional reality is made objectively available and subjectively plausible for new individuals.

Another aspect of Berger and Luckmann's analysis is important for investigating how the outdoor teaching practices with loosely supervised learning settings are set up for students as ordinary schoolwork. A controlling character is inherent in the very nature and the objectified character of the institutions. The objectified institutions appear as undeniable and persistent external structure that have power over the individual by the sheer force of their existence; "[t]he institutions are *there*, external to him, persistent in their reality, whether he likes it or not" (Berger & Luckmann, 1966, p. 78). Yet, it is likely that the individuals will deviate from the institutional orders set by others or set up by the individual. Thus, specific control mechanisms are usually attached to the most important institutions in the form of various sanctions. The established sanctions enable institutions to claim authority over the next generation of

individuals; after becoming socialized into the institutional order independent of the subjective meaning they may give to any situation.

In this dissertation (Study III), the outdoor teaching practices were investigated regarding how they allow turning outdoor learning that students initially consider uncommon and alien to ordinary schoolwork as normal part of it. Many characteristics comprise the formal structure of schools, which has been institutionalized over the past century around the world; modern school systems share many similarities in their education curricula, age-graded classes, systematic testing and professional training of teachers (Davies & Guppy, 2010; Meyer & Ramirez, 2000). Whereas some of the characteristics of the instructional practices investigated in this research point to the institutionalized structures and sanctions typical to schools, the outdoor settings where students work out of earshot of the teacher are still contradictory to the controlling nature of schooling. Yet, both are possible at the same time. This is so, because the school system a special type of institution. Within schools, the formal structures and actual activities in schools are "decoupled" in such a way that school activities are considered to fulfil the formal boundaries while the actual instruction is not closely monitored (Meyer & Ramirez, 2000; Meyer, Boli, Thomas, & Ramirez, 1997). Even though some aspects of schools are controlled and standardized with formal structures, the actual practices and activities in classrooms often diverge from these formalities. Through this decoupling, schools keep a face of legitimacy while at the same time the teachers have a relatively large amount of autonomy in their classroom activities (Davies & Guppy, 2010). This is reflected in the classroom activities, during which the practices and actions of the teacher alone affect the interactional setting and how students perceive the schooling (e.g. Mehan, 1979).

The preceding emphasizes the role of a teacher's choices and practices for setting up new or uncommon educational practices within the existing structures of school institution. Teachers may balance between practices that follow the conventional structures and deviate from them, as is the case with extensive and relatively loosely supervised fieldwork practices in the present dissertation. This dissertation investigates how the challenge of balancing students' freedom and control may be approached in the context of extensive outdoor education which is organized as part of ordinary schoolwork. The analysis of teachers' choices and instructional practices brings the question of balancing of freedom and control into the practical level of science teaching. Accordingly, this also allows the findings about students' opportunities to be discussed in terms of various science teaching settings in which more authority and control is shifted to students.

3 Objectives of the research

The aim of this dissertation was to build up an understanding of the opportunities for science learning and teaching in settings in which students work out of earshot and out of sight of the teacher. The main objective was to investigate how working in less supervised settings away from the teacher can allow students to access science learning in authentic and affectively relatable and meaningful ways. More specifically, the objective is to investigate the interactional opportunities to participate in doing science in culturally feasible ways that expand beyond the conceptual and cognitive dimensions of learning, and how these processes may be enabled within formal education in outdoor environments.

The research questions arose from a research project on outdoor education and students' observation and interaction processes during fieldwork. The empirical analyses were based on two main data sources: (a) the observations of students during field trips when they worked independently away from the teacher, which allowed particular phenomena to be particularly visible enabling them to be studied and (b) interviews of teachers who implement extensive outdoor teaching in their biology courses. A summary of the research design and the main differences and similarities between the articles is presented in Table 1.

In short, the objectives, the specific research questions and the related individual studies can be described as follows:

Objective 1: To study students' ways of accessing science learning/doing in meaningful ways that arise among them in the physical absence of the teacher.

How do students use non-conceptual but culturally possible ways to connect science learning processes to their everyday world? (Study I)

How do students cope with authoritativeness as it is manifested in the evaluative feedback? (Study II)

Objective 2: To study the instructional practices and pedagogical choices that allow the balance to be shifted from teacher control towards less supervised learning settings.

What pedagogical and organizational means do fieldwork-oriented biology teachers use to integrate outdoor teaching into the formal teaching of biology? (Study III)

Table 1. Comparison of the core elements between the articles.					
Article	**Focus**	**Main theoretical concepts**	**Research questions**	**Data source**	**Method**
The resurgence of everyday experiences in school science learning activities (Study I)	Students' culturally and affectively meaningful ways of accessing science while working away from the teacher	Primal premises of knowing Commonsens e level of thought Carnival sense of life	How do students use non-conceptual but culturally possible ways to connect science learning processes to their everyday world?	Video recordings, field notes and group interviews from two student groups during outdoor oriented biology course	Interaction analysis of students' interactions, ethnomethodologi cal stance
" How stupid can a person be?" – Students coping with authoritative dimensions of science lessons (Study II)	Students' culturally and affectively meaningful ways of accessing science while working away	Dialogism Carnival sense of life	How do students cope with authoritativeness as it is manifested in the evaluative feedback?	Video recordings, field notes and group interviews from two student groups during outdoor oriented biology course	Interaction analysis of students' interactions, ethnomethodologi cal stance
How fieldwork-oriented biology teachers establish formal outdoor education practices (Study III)	Instructional practices and pedagogical choices in loosely supervised learning settings	Process of institutionalizat ion	What pedagogical and organizational means do fieldwork-oriented biology teachers use to integrate outdoor teaching into the formal teaching of biology?	Interviews from three biology teachers experienced in outdoor teaching	Thematic analysis of teachers' discourse of outdoor learning

4 Methods

This dissertation draws on data gathered within a research project on biology outdoor education. The data consist of case studies of three outdoor-oriented teachers and a study on an outdoor biology course in which the activities in the forest comprised most of the lessons. These loosely supervised settings in which the teacher was not physically present most of the time offered analytical opportunities to investigate phenomena that might not become visible in an ordinary classroom interaction although they were universally culturally present. The specific phenomena of interest for this dissertation arose from the data, and the research questions and theoretical underpinnings were chosen accordingly. Taking the focus on the students' initiatives seriously—and not studying learning processes as more or less successful fulfilment of instructional goals—has its consequences on the research design and requires a certain analytical stance, as described later in this chapter.

4.1 Participants

The participants in the research include three teachers from two schools and two classes of grade eight students aged 13–14 years old from one of the schools. The schools were Finnish secondary school (grades 7–9). The schools were selected for the research project on outdoor learning because the ecology units of their biology courses mostly consisted of fieldwork. As fieldwork and other out-of-school activities are not that common in Finnish secondary schools (Uitto & Kärnä, 2014), the implementation of the course was quite different to the average pedagogical arrangements in biology courses in Finland. All the teachers had master's degrees and were qualified to teach biology and geography in Finnish secondary and upper secondary schools. They had many similar practices in organizing their teaching, partly because of their common history in developing the curriculum in one of the schools with a long tradition of using outdoor environments in science (biology) teaching.

The video data used in Studies I and II came from observations of a group of four students in one classroom. Based on the post-course group interviews, as well as informal discussions with the teacher, the students in the group from which the examples in this study were derived were not very science-oriented and perceived the assessment as an important factor motivating them to complete the tasks well. Because it has been shown that talking about science and technology is a sociocultural phenomenon

irrespective of individual characteristics (Roth, 2013), knowing the individual characteristics of the students is not important for the purpose of this study. The sociological stance used in the analyses is described in more detail in Chapter 4.4.

The participation was voluntary for the teachers and students and based on informed consent. The research complied with the guidelines of the Finnish Advisory Board on Research Integrity (2012) in terms of respecting the autonomy and anonymity of research subjects, avoiding harm and ensuring the privacy of data collection and safe storing of the data.

4.2 Data collection

The data used in Studies I-II were collected from the ecology unit of an eighth-grade biology course (of students aged 13 to 14 years). The data consist of video recordings and field notes of the lessons and group interviews after the course. During the course, the lessons consisted of fieldwork during which the students worked in the recreation area (an urban forest nearby the school) most of the time independently in small groups without the direct presence of the teacher. The educational goals of the course were consistent with the Finnish national core curriculum (FNBE, 2016). During the first part of the course (8 lessons), the students were given tasks and small inquiries related to the ecological phenomena in the forest. There were single, 45-minute and double, 90-minute lessons, which affected the contribution of the tasks and other pedagogical choices. The lessons usually started with short instructions in the classroom, after which the students and the teacher walked 5–10 minutes to a nearby forest. In the forest, students worked in groups of three or four, and depending on the task, provided the teacher with brief reports. The teacher occasionally gave further instructions through a whole class WhatsApp group. Also, in some lessons the students reported their answers in the WhatsApp group. Most of the small tasks were evaluated, each contributing 10% to the final grade (the rest of the grade consisted of the individual plant collection task and the larger inquiry in groups). During the latter part of the course (8 lessons), the students worked in the same groups to perform a small inquiry based on their own research question about the forest.

The researcher (biology educator) met with the students at the beginning of the course to explain the research and gather questionnaire data (not used in this research). The video recording began during the second lesson. The students were videotaped using two cameras operated by the researcher and a research assistant; neither of them participated in the teaching. Students also were audiotaped with an external microphone for each student, which

allowed the videos to be recorded from some distance, to minimally interfere with their activities. When asked about the presence of the researchers and cameras after the lessons and in the group interview, the students reported no effect on their activities and said they had forgotten the recording quickly. For example, in the group interview, when the students were shown short clips of the video data, they laughed upon realizing that all their conversations had indeed been recorded. All agreed that the recording had no effect; for example, Mark stated that he "completely forgot the recording at some point at the beginning," and Max confirmed that "as you could see, we didn't talk particularly nicely there." In the post-course interviews, the student groups were asked about how were they feeling and what they were thinking during the fieldwork, as well as more generally how they found the outdoor learning and related freedom as well as the grading of the tasks. The data sources used in Studies I and II consist of video- and audio-recorded lessons of two groups of four students, fieldnotes on the topics and the tasks of the lessons, and group interviews with the students after the course. The video and audio recordings were synchronized. Raw transcripts of the lessons were produced using Transana 3.10 software. Selected episodes (see the next section) were later transcribed using a conversation-analytic system (Selting et al., 1998).

For Study III, the three teachers were interviewed about their outdoor teaching practices. The interviews were semi-structured in a way that pre-designed questions were used to cover all the areas of interest (Appendix 2). However, the questions were open-ended, and the interviews were directed by the teachers' responses in an informal manner. Teachers were asked about (a) their experiences and how they used fieldwork in their teaching, (b) their views on and justification for fieldwork as part of biology education, and (c) the challenges related to fieldwork. It was emphasized that the teachers' practices were not being evaluated and they were asked for the interviews because they were known to use outdoor teaching. The interviews took about an hour each. The interviews were audio recorded and transcribed.

4.3 Data analysis

The analyses of Study I and Study II are based on the interactional analysis of students' interactions (Jordan & Henderson, 1995). The post-course interviews were used to triangulate some of the findings to a small extent. In interactional analysis, the samples from the selected lesson were analyzed in joint sessions. The analysis began by identifying important

themes in the data source, arising from the initial notion that working away from the teacher provided students with opportunities that might not be encouraged or even possible in a typical classroom and face to face interaction. In the case of Study I, the identified themes were related to students' interactional and cultural resources that did not arise from the science task but were still frequently drawn from by the students, such as coming up with different imaginary narratives or playing around. In the case of Study II, the identified themes were related to students' reactions that confronted the teacher in some way and the requirements for correct answers, such as students getting angry at the evaluative feedback. After discussing the emerging sense of what is going on in the videos, tentative hypotheses were formulated in regard of the themes of interest. Representative episodes of the themes were selected for close analysis and to be presented in the articles. As required by the method, the entire database was then scoured to find evidence that disconfirmed or was consistent with the tentative hypotheses (Roth, 2005). Repeated meetings were held to discuss emergent understandings generally and any alternative understanding specifically. The research reports of the studies are the result of this iterative process of joint analysis, writing, and discussing the emergent understanding.

In Study III, the interview data were analyzed thematically, identifying, analyzing and reporting patterns within the data (Boyatzis, 1998; Brown & Clarke, 2006). The process was iterative and ended up in the interpretative consensus of three researchers. The analysis followed the six phases as suggested by Braun & Clarke (2006), presented in Table 2.

Table 2. The thematic analysis of the interviews.

Phase	Analytic process
1. Becoming familiar with the data	The interviews were transcribed and then read several times.
2. Generating initial codes	Initial codes were produced by one researcher.
3. Searching for themes	Themes were searched from the coded data and the coded data extracts were sorted into relevant themes and subthemes.
4. Reviewing themes	The themes were reviewed and revised by three researchers to assure their internal and external homogeneity by comparing them in relation to the data segments included as well as to the entire data set.
5. Defining and naming themes	The themes were refined, named and interpreted in relation to the research questions.
6. Producing the report	The final report was produced, and the data extracts were included in it in order to enhance the transparency of the results.

4.4 Analytical framework

Studies I-II rely on the analysis of the interaction among the students, between the students and the teacher (including mobile messages) and between the students and their surroundings. In a cultural-historical approach, the interaction between individuals, the interaction between individuals and the task or environmental object at hand is closely related with historically shaped cultural artifacts. The most notable of these artifacts is language, in the form of spoken utterances as well as signs, symbols and text. Typically, the material and cultural artifacts are considered to be the *mediators* of the intersubjective interaction; "they are 'tools' broadly conceived, and the master tool is language" (Cole & Engeström, 1993, p. 9). However, the role of language as merely a mediator of interaction can be problematized, something that Vygotsky raised during his last few years (Roth & Jornet, 2016). Instead of language mediating between individuals and between individual and the world, "language is an integral part of this world; and knowing a language [...] is indistinguishable from knowing one's way around the world more generally" (Roth & Jornet, 2016, p. 84). Thus, intersubjectivity is inherently grounded in language as shared communicative competence that constitutes the basis of both individual and intersubjective consciousness. All in all, language fundamentally defines the nature and options of how cultural interaction works.

For Vygotsky, higher psychological functions of humans are social prior to being functions of an individual mind; "true direction of the development of thinking is not from the individual to the social, but from the social to the individual" (Vygotsky, 1934/1987, p. 36). Thus, the individual mind in the social interaction is as much as the social and cultural world is in an individual mind. Following this logic, the analysis of cultural phenomena—how any cultural structure is produced and accounted for—does not attempt to get into the individual mind. Instead, social phenomena can be revealed to be studied as they are made visible and addressed by the members of the society in their actual practices (Garfinkel, 1988). In his work, grounded in conversational analysis and phenomenological philosophy, a sociologist Harold Garfinkel described the analytical method, *ethnomethodology,* that investigates social structure through "rational properties of indexical expressions and other practical actions as contingent ongoing accomplishments of organized artful practices of everyday life" (Garfinkel, 1967, p. 11).

Traditional "formal" qualitative and quantitative methods to analyze social interaction are typically inadequate to describe the processes through which the social practice is actually formed and thereby what it is *for the*

actors themselves (Garfinkel, 1988). The dilemma here is that because traditional approaches interpret the social interaction through special interpretive methods, they presuppose that without these methods "there is no orderliness in the concrete activities" (Garfinkel, 1988, p. 105). By using the specific methods—available only to the them—the researchers assume that the "real immortal society is only specifiable as the achieved results of administering the policies and methods of formal, constructive analysis" (p. 106). This may lead to a depreciation of what is happening for the actors. For example, in science education research—a field of limited use of the ethnomethodological approach—there is a risk that the formal analytic technologies are used to report and theorize the social order in ways that are irrelevant to social actors. On the contrary, the actors lack the formal qualitative or quantitative tools; "rather, they 'merely' have their ethnomethods; and it is these ethnomethods that produce the order" (Roth, 2013, p. 9). Here, ethnomethodological approach takes the stand that the same processes and practices that the actors in the society use to make the social interaction available and accountable for each other, can be used to make visible the social structure for the researchers as well (Garfinkel, 1988).

Ethnomethodological research investigates how the social order is structured *from the inside* and how it is unfolding and being accounted for by the actors who are producing it. The only methods needed for this are the same methods through which the actors are producing the social structures themselves—that is the *ethnomethods* of people's everyday interaction. As already mentioned, social activities should not be theorized from the perspective of the individual but from the perspective of the interactive society (Vygotsky, 1934/1987). Respectively, the intelligibility of the social order is "achieved in and through the enactment of recognizable practices, not through interpretive processes in the minds of individual actors" (Rawls, 2002, p. 60). The language is the foundation of any intersubjectivity, and on the other hand, the origin of language is in the dialogue (Bakhtin, 1986). Thus, the social structure and the cultural reality of people is produced and accounted for through language. Accordingly, the *ethnomethods* of social interaction—how actors account for their linguistic interaction and what emerges from this process—make the interaction visible (Garfinkel & Sacks, 1986) and thus allows it to be analytically studied. Because the participants make available to each other what they do and what structures they are currently making and why, researchers need to have the same competencies. That is, they do not require any special interpretive methods, but the analytical process requires

them to hear the participants in the manner they hear (understand) each other.

To analyze the interaction ethnomethodologically, the smallest unit of analysis that makes sense is a pair of communicative turns. The turn pair allows attending to the irreducible social nature of the speech act; the value of an utterance (verbal or written) in and to a conversation is tied to its social evaluation, which the listeners make available in their own following turn or turns (Vološinov, 1973). Thus, the significance of the social action and the actors' point of view is tied to the social interaction instead of being a thought belonging to individual actors (Rawls, 2002). Analyzing the relationships between pairs of utterances, that is, analyzing the way in which members to the conversation hear what is being said, allows us to understand what was treated as factual instead of trying to interpret the (private) thoughts of the speakers. Similarly, not even the actors have access to the intentions and motivations of other actors. Yet, the interaction and its social consequences unfold to the actors. The study of emerging cultural phenomena can and should be reducible to what is actually happening in the interaction and "what is objectively available for everyone to observe and to account for" (Roth, 2013, p. 123).

Table 3 presents an example of data fragment (see Study II) and its analysis from the above described stance. In the example, a student (Tom) points to a beer can that he has noticed in the forest, referring to it as a very rare observation with a particular phrase and accent (turn 17; very rare also referring to a Pokémon game, very popular in Finland at the time of the data collection). Rather than interpreting this locution, suggesting that Tom has made a joke about the beer can, the role of the statement from within the exchange itself is brought out by following how the subsequent speaker responds to it (turn 18).

Table 3. An example of data analysis from an ethnomethodological stance.

Data fragment	17 Tom: ((*notices a beer can*)) There's a very rare ((*in English, overacting the Finnish accent*)) 18 Max: ((*laughter*)) Ye-ah. It is a koskenkorva boletus ((*Koskenkorva is a Finnish vodka brand*)) 19 Tom: ((*laughter*)) [Koskenkorva boletus 20 Max: [Err (.) extremely intoxicating 21 Jeff: ((*laughter*))
Analysis of the fragment	Max's laughter (turn 18) is the first reaction after Tom's statement. Laughter is not randomly produced as an interactional resource. Laughter, and other forms of parody, is an event within a more encompassing event makes salient (a) an invitation for others to laugh and (b) the recognition and acceptance of that invitation (Jefferson, 1979; Roth et al., 2011). Max's laughter can be heard as an acceptance of an invitation to laugh in Tom's statement and an agreement that it was nothing serious but some sort of parody. He then makes an affirmative statement ("Ye-ah"). After this, the next sentence ("It is a koskenkorva boletus") can be heard as a response and expansion to Tom's initiation of parody and joke. To this, Tom then reacts with laughter (turn 19), which indicates that what Max said was perceived as joke. Tom also repeats the words "koskenkorva boletus." In this case, although it might appear that he produces a mere repetition, pure repetition does not exist in language and every repetition constitutes difference and has a function (Roth, 2015a; Vološinov, 1973). With his laughter and repetition Tom both confirms the joke and joins to it. Once the joke has been mutually confirmed, Max's statement (turn 20) can be heard as an expansion of the joke. Jeff then joins the conversation by laughter (turn 21), reaffirming that Max's expansion was heard as joke.

Studies I and II take the above-described ethnomethodological approach in the analysis of the sections of students' interactions to show how they connect the learning situations to their everyday world or how they cope with the authoritative tensions arising in the interaction. The focus—and the only possible scope—of the ethnomethodological analysis is in the social practices and related/emerging cultural phenomenon. Likewise, the results of the analysis are applicable (only) at the social and cultural level. This is so, because "[a] population is constituted not by a set of individuals with something in common but a by a set of practices common to particular situations or events" (Rawls, 2002, p. 60). The cultural, interactional practices which participants make and make visible are analyzed, not the psychological (mental) states of individuals. Because dialogical interactions and tensions between the authoritative teacher statements and the students' uptakes thereof are interactional phenomena, they constitute *cultural possibilities* rather than phenomena specific to individual students or the teacher. Therefore, the results of these analyses are not limited to a

single lesson. On the contrary, all interactional resources that participants produce are inherently cultural-historical and ideological, and therefore transcend the individual case (Rawls, 2002; Vološinov, 1973).

In Study III, the focus is on the practices reported by the teachers, not the actual observed practices. Therefore, the methodological approach is different from the first two studies. The thematic analysis (Boyatzis, 1998; Braun & Clarke, 2006) focused on the semantic content of the data, that is, the experiences of and meanings given to outdoor learning by the teachers, regarded as the cultural reality for the participants. However, in addition to the explicit meanings, the aim of the analytic process was also to identify and interpret underlying ideas, assumptions and conceptualizations in the participants' speech, which Boyatzis (1998) refers to as analyzing themes at a latent level. The teachers' discourse of outdoor learning is primarily a cultural discourse, in this case a discourse about the practices that allow extensive outdoor teaching part of formal teaching. Therefore, the discursive accounts are not isolated to the three teachers but allow understanding of the investigated practices at more general levels of formal schooling (c.f. Hsu & Roth, 2009).

4.5 Remarks on credibility and research ethics

The dissertation focus on the interactional (cultural) phenomena that allow students to access science learning in affectively meaningful ways without direct instructional input on the teacher's part (Studies I-II) as well as on the approaches through which teachers can balance control and freedom in an out-of-school learning setting (Study III). The epistemological and methodological perspectives of the qualitative study of this type is different from the subject-object dualistic perspective according to which the purpose of research is to find an objective world that exists in corresponding representations separately from language, culture and discourse (Huttunen & Kakkori, 2020). Instead, the value of this research is in evoking new kinds of understanding and thinking that transfer to understanding the phenomena in a more general context within the same cultural premises that they were originally observed. The credibility of the methodology thereby arises from the rigorous analysis of the social and cultural practices so that the same rational accountability through which the participants make sense of each other is reproduced in the research account (Roth, 2015b).

The ethnomethodological analysis revealed the interactional opportunities for the students to cope with authoritative dimensions and connect the science learning with their everyday experiences in non-

conceptual but culturally relevant ways. These analyses did not require any special interpretive method; they required the analyst to hear the participants in the manner they heard (understood) each other (Garfinkel & Sacks, 1986; see previous section). Because the research focuses on what participants make available to others, who already need to understand what is made available, the focus is on social phenomena through and though. Thus, we did not need to investigate the private motives, thoughts or concepts of individual actors but the interactional phenomena as cultural possibilities for the actors. The significance of these phenomena as social actions does not belong to individual actors or to the actors' point of views but can be theorized at a general level as social phenomena. This is so because all the interactional resources that the participants produced are inherently cultural-historical and ideological, thereby transcending the individual case (Rawls, 2002; Vološinov, 1973). Therefore, while the studied phenomena were observed across the lessons and highlighted in the episodes selected for the analyses, they were not limited to these individual cases. What was possible and could be observed in these particular cases is possible in other social settings and with people as well; "It can be seen that... what is recognizable to one ego has to be, on principle, recognizable to every ego" (Husserl, 1976, p. 102). However, the findings do not allow conclusions about the prevalence of these phenomena among different students, schools or different instructional settings.

Study III, investigating the pedagogical choices that allowed balancing the freedom and control and less supervised outdoor teaching to be set up as an institutionalized practice, was drawn from the analysis of the interviews with the three teachers. Because the teachers' discourse about the outdoor teaching practices is typical of the culture—the culture of institutionalized formal teaching in particular—the findings are not isolated to these teachers but allow understanding of the practices of formal education at a general level (c.f. Hsu & Roth, 2009). The three teachers were known to use outdoor teaching extensively during their biology courses as compared with typical biology teaching (Lloyd et al., 2012; Uitto & Kärnä, 2014). These teachers were selected for the study, because theoretical understanding of the specific (cultural) phenomenon at a broader and more general level can be acquired by focusing on atypical but interesting cases, instead of studying average cases (Flyvbjerg, 2006). Whereas the earlier studies present challenges on balancing control and freedom and applying outdoor teaching (e.g. Glackin, 2017; Lock, 2010; Scott et al., 2015), the present study offers theoretical and practical perspectives on how these challenges can be overcome. The consequences

of students' freedom (and control) are exemplified in the analyses of interactions in the video data (Studies I-II).

Formal ethical protocols were applied for and consent forms (Appendix 1) for the participation and the use of data were obtained, in accordance with the guidelines of the Finnish Advisory Board on Research Integrity (2012). Some of the observed joking, derision of the teacher and grotesque humor were such that it would likely not have been possible in the direct presence of the teacher but might cause disciplinary problems. For example, the expressions that related to culturally taboo themes about sexual organs or sexual intercourse are typically considered to be swearing, the use of which is restricted in society (Ljung, 2011). While we do not want to endorse the use of offensive language or jokes, the research shows how even this kind of discourse may have a function for students in transforming their everyday cultural experiences to taking part in science learning activities in meaningful ways. Even if such style of speech was abundant in the reality of students' everyday lives or even school interactions, here it had a significance for engaging in science learning.

One might question whether the video and audio recording affected the observed interactions among the students. Earlier studies have shown that participants get used to video recordings quickly and the reactivity to researchers is greatly reduced after a short while (e.g. Praetorius, McIntyre, & Klassen, 2017; Samph, 1976). In the present study, the students were followed and recorded throughout the course in several lessons. According to the repeated remarks from the students (see Chapter 4.2), it is justifiable to assume that the recording and the relatively distant presence of the researchers did not influence the students' interactions in a way that significantly changed its content or altered the atmosphere from what it would normally have been.

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5 Overview of the original articles

This dissertation consists of three individual studies. The first two address the interactions among the students during outdoor biology lessons in the absence of the teacher while the third one explores the instructional practices that enable such learning settings to be applied within the formal education. Study I examines the non-conceptual and non-cognitive but culturally intelligible processes through which students connect their everyday life with doing science. Study II investigates the interactions that allow students to cope with the perceived authoritative dimensions of science teaching and moderate the potential negative outcomes. Study III explores the instructional practices and choices of balancing students' freedom and control reported by teachers who use extensive outdoor education in biology teaching.

This section elaborates on the main findings of each study in parallel with the research aims. The findings presented here are overviews and are summarized in Table 4. Detailed descriptions of the analyses and the findings are presented in the corresponding articles and, thus, overall evaluation of the validity of the observations and the analyses should be done on the basis of the articles.

5.1 Study I: Connecting science learning activities with everyday experiences

Study I investigated the opportunities for students to connect science learning processes to their everyday experiences through non-conceptual but culturally possible ways. The study showed how students drew on a variety of cultural resources that initially manifested as what might be called "off-topic" interactions but where connected to doing and learning science by contextualizing and transforming the science activities in affectively meaningful ways.

Two student groups were observed during outdoor science learning activities out of the earshot of the teacher. While performing given tasks, different forms of verbal and physical interaction arose among the students that were not directly related to the conceptual and academic content of the tasks at hand. Three specific forms of such interaction were analyzed to show how these allowed the resurgence of nonconceptual, but culturally meaningful everyday experience. The study showed how these experiences allow students to participate in science learning in affectively meaningful

ways that could also serve the purpose of learning. These forms of interaction included (a) the bodily exploration of the physical environment, (b) the grotesque, bodily humor to temporarily overturn the seriousness of science learning, and (c) the contextualization of learning through narratives.

Students actively interacted with the physical environment over the course of the lessons. Some of the interaction was related to and required by the tasks themselves, but many such bodily explorations were of a non-teleological and spontaneous nature and were seemingly unrelated to science learning at first. Yet, the continuous bodily experimenting functioned as a way for students to relate to the familiar lifeworld. This is so because the intuitive and self-evident sense experiences lay the fundamental foundation for relating to the world and common sense (Husserl, 1989; James, 1907). However, some of the emerging explorations were shown eventually to have value as a means for students to gather scientifically-relevant knowledge of the environment.

Another nonconceptual but meaningful cultural resource that arose in students' interaction was the use of humor. Grotesque humor, exaggeration, and abasement—often associated with bodily laughter to overturn the authoritative seriousness (Bakhtin, 1984a)—were shown to function as a means to contextualize science learning experiences within the mundane experiences of life. Unlike in previous research, the humor was not invoked or accepted by the teacher (c.f. Roth et al., 2011) or neither was it stemming from the grotesque characteristics of science contents (c.f. Weinstein & Broda, 2009), but was invoked and maintained by the students to degrade and overturn the seriousness of science learning. Yet, as the absence of the teacher allowed the joking to remain within the sphere of students' mutual interaction, the overturning was only temporary paralleling the carnival sense. The serious, institutional, and authoritative dimensions of science learning were not directly defied, and the use of humor was possible without hampering the commitment to the science task.

The third form for students to draw on cultural resources of everyday experiences was the use of narratives to contextualize the learning activities and connect them with everyday experiences. The inspiration for the narratives derived from the task at hand, from the physical environment or the familiar cultural resources, or from all of them at the same time. Use of narratives or narrative elements were shown to function as means to interpret and transform the science activities from the standpoint of students' everyday cultural lives (Ricœur, 1991). The findings showed how students narrated their tasks (e.g. finding bugs) drawing from the narratives they were familiar with. The study showed how the scientific knowledge,

in the form of searching for the correct answers to the tasks, and narratives did not exclude each other but coexisted temporarily within students' activities.

5.2 Study II: Coping with authoritative dimensions of teaching

Study II investigated how students cope with authoritativeness as it is manifested in the evaluative feedback from the teacher. The study showed how working out of earshot of the teacher allowed students to react in ways some of which would not be possible in face to face interaction without causing disciplinary problems. In the outdoor setting, they become visible and were shown to function as potential means to moderate the alienation deriving from the authoritative dimensions of science teaching.

Two student groups were observed during a lesson during which they communicated with the teacher through mobile messages. Their task was to observe and identify mushrooms, while the teacher evaluated the correctness of the answers and required more arguments for the identification. In these mobile-aided exchanges, the authoritative dimension of science, perceived as a monologic form of knowledge with a single correct answer, was present (Barton, 2009; Ford & Wargo, 2012). This was occasionally perceived as negative feedback or caused frustration among the students—typical in moments when students faced evaluative feedback from the teacher or are struggling to find the right scientific answer or the correct way to proceed with the task (Bellocchi, 2018; Bellocchi & Ritchie, 2015; Brown & Melear, 2006).

The results of the study showed three ways for students to cope with these authoritative dimensions of science teaching as they rise during the learning activities. These ways were used by the students as if they were able to put the negative emotions of frustration aside, showing them as opportunities to experience and actualize their relationship to science learning in affectively meaningful ways that may also support the purpose of learning.

First, it was shown how the authority of the teacher—paralleling the authoritative dimension of science—could be temporarily opposed though abusive language and mocking the teacher. Second, humor and laughter were used to question the seriousness of science learning. This was manifested as frequent joking about observations about the environment or picking up words or expressions from the teacher's messages and joking about them instead of focusing on the evaluative content and demands. Both these forms of reaction—opposing through the derision or

overturning the seriousness of science learning—were shown to overturn the authoritativeness teaching, paralleling the authoritative dimension of science.

The third way of overturning the authoritativeness was more directly related to the authoritative dimension of scientific knowledge. Following the works of (a) Foucault (1977) concerning the intricate relationship of knowledge and power and (b) Bakhtin (1984a) on the power of laughter and ridicule to degrade the institutional power, it was shown how the students reversed the power of authoritative truth and empowered themselves when completing the task. The students turned the tables of knowledge/power by exhibiting and referring to types of knowledge that they had more of than the teacher. This knowledge included things that were not directly related to the task, such as superior mobile typing skills, but also knowledge and power that manifestly related to the science task were used to question the teacher's requirements at times, when the students perceived to command such knowledge.

In the study it was shown how all these reactions and exhibiting power functioned as potential ways to cope with the authoritative dimensions of science teaching. This was so because overturning the authoritativeness was only temporarily in a way that after the initial reactions, the students still followed the teacher's instruction and requirements and improved in the task. In the light of Bakhtin's (1984a) analysis of *carnival sense of life*, the study showed how these interactions allowed students to temporarily enter the "the sphere of utopian freedom" (Bakhtin, 1984a, p. 89) without a conflict with the authoritative requirements. In the end, the demands were followed as if the arising frustration had been coped with.

5.3 Study III: Supporting students' freedom during formal teaching

Study III investigated the pedagogical and organizational means through which teachers could integrate the relatively loosely supervised outdoor teaching settings into the formal biology teaching. Three outdoor-oriented teachers were interviewed to understand the successful implementation of the teaching practices that are considered challenging by many teachers (e.g. Glackin, 2017; Scott et al., 2015). The findings of the study showed that certain pedagogical choices allowed the outdoor teaching to be used as part of formal education and the fear of losing control in outdoor settings was overcome. Two approaches were analyzed in terms of how they allowed teachers to institutionalize—within the framework offered by

Berger and Luckmann (1966)—outdoor teaching practices as part of ordinary schoolwork while the students retained the sense of freedom.

First, outdoor teaching was organized and actively communicated to students in such ways that it would be represented as ordinary teaching for students instead of an add-on or merely fun trips. In this respect, the regularity of the fieldwork, carefully designed tasks, the assessment practices involved in most tasks and explicitly making the connection with the tasks and the curriculum were important ways to legitimize and objectify the outdoor learning for students as an important and normal form of schooling. This allows the initially unfamiliar outdoor learning to be transformed into a habitualized practice for students in a way that it paralleled the institutionalized structures of the formal school to which students are accustomed.

The second, concurrent, approach emphasized by the outdoor-oriented teachers was the need to balance the control and the freedom of students. Despite the means to institutionalize the fieldwork practices and create structures for learning, students' opportunities to work relatively freely in nature appeared pivotal in enabling authentic learning experiences in nature. The freedom resulted from the student groups moving around in a (possibly restricted) large area while the teachers moved between the groups, leaving many groups to work a lot of time without direct supervision, out of sight and out of earshot of the teachers. Therefore, students found it possible not only to move around and but also to participate in the task on their own even at the expense of not fully concentrating on the task all the time. At the same time, controlling practices, such as carefully designed and instructed tasks, assessment and communication through mobile messages, functioned to ensure and support the engagement with the learning activities.

Consequently, an important aim was shown to be granting students an "illusion of freedom". Within this sense of freedom, the authentic learning experiences could be actualized while ensuring enough concentration and obedience to complete the tasks. Here, the emphasis on trusting and positive relationship with the students as well as the expansion of learning goals from merely learning of detailed knowledge to enabling authentic science experiences appeared as an important requirement.

5.4 Summary of the main results

In conclusion, the present dissertation showed what opportunities aroused students when working out of earshot and out of sight of the teacher and

how such learning settings can be incorporated within formal practices of outdoor science education.

The findings from Studies I and II showed how working independently in a loosely supervised setting provided students with opportunities to contextualize science learning activities in culturally and affectively meaningful ways or allowed students to cope with the authoritative dimensions of science teaching. Many of these phenomena—being initially off-topic activities or exceptionable in face-to-face interaction with the teacher—were possible or at least particularly visible in the outdoor settings in which students were given considerable freedom. The findings from Study III showed that certain pedagogical and organizational means allowed the atypical, relatively loosely supervised setting to be institutionalized so that it students would treat it as ordinary schoolwork while still having a sense of freedom and authenticity. The findings from all three studies are summarized in Table 4 and discussed in the subsequent chapter.

Table 4. Summary of research questions and main findings.	
Main research questions	**Main findings**
1) How do students use non-conceptual but culturally possible ways to connect science learning processes to their everyday world? (Study I)	The analysis revealed three forms of connections made with and related to the everyday world: (a) the bodily exploration of the physical environment; (b) grotesque, bodily humor as a way to temporarily overturn the seriousness of science learning; and (c) the contextualization of learning through narratives.
2) How do students cope with authoritativeness as it is manifested in the evaluative feedback? (Study II)	The analysis revealed three specific ways for students to react to the authoritativeness of teacher's evaluative feedback: (a) using abusive language and direct mocking of the teacher, (b) drawing on humor and laughter to oppose and degrade the teacher's authority, and (c) exhibiting knowledge and power of their own to further overturn the authority.
3) What pedagogical and organizational means do fieldwork-oriented biology teachers use to integrate outdoor teaching into the formal teaching of biology? (Study III)	The analysis revealed three aspects that allowed institutionalization of outdoor teaching practices while maintaining the sense of freedom required for students' authentic experience in nature (a) regularity of outdoor learning instead single fieldtrips is required to achieve all the benefits. (b) justification—e.g. through the means of evaluation— is necessary to explicitly show for the students that learning outdoors is important and normal way of learning (c) promoting the freedom of students may serve diverse positive outcomes, provided that the control is produced through habitualization, well-planned tasks, assessment, and for example mobile-based interaction with the teacher.

6 Discussion

In this section, the main findings of the dissertation are discussed in relation to the outlined research objectives and in terms of their contribution to the relevant research. The section is followed by highlighting the implications for science education and contributions for potential future lines of research.

The main objective of the dissertation was to investigate how less supervised learning settings function in allowing students to access science learning in authentic and meaningful ways. By examining the interactional processes and resources that students draw on in the physical absence of the teacher (Studies I-II), this dissertation provides empirical evidence of how students actualize an affectively meaningful relationship with doing and learning science in ways which are (a) non-cognitive and non-conceptual but yet culturally relevant and which (b) do not stem from the instructional inputs of the teacher but arise from the students' agentic positions towards (or against) the science and the teacher. Taking outdoor biology teaching as an example, the dissertation explores instructional practices, through which authentic and relevant science learning can be coupled with relatively free forms of interaction that support students' agentic experiences within formal education settings (Study III). Next, the results will be discussed according to the two objectives of the dissertation.

6.1 Objective 1: To study students' ways relating to science learning that arise in the physical absence of the teacher.

6.1.1 Accessing science learning in affectively meaningful ways

The results from Studies I and II present a variety of means for students to make affectively meaningful connection to doing science that stem from the familiar experiences of the students and not from instructional support. Findings from Study I showed how students can connect to doing and learning science in ways that do not stem from the conceptual aspects of science but from the cultural recourses beyond the conceptual and cognitive side of learning. Students drew from the humorous and grotesque sense of life, explored the surroundings through bodily excursions and conceptualized science through narrative interpretations. Respectively, findings from Study II showed how humor, derision and abusive language

were particularly utilized when overturning and coping with the authoritative dimensions of science teaching. All these interactions arose in the middle of doing and completing the science tasks given by the teacher. The two were interweaved; for example, humorous jokes or narrative elements followed the discourse on science task and vice versa. Moreover, the students initiated them without instructional inputs or acceptance on the teacher's part. The teacher was not only needed for these interactions to occur, but at many times it was the absence of the teacher that actually allowed students to behave as they did. Here, the findings suggest that the learning settings that are not tightly controlled by the teacher but more or less loosely supervised can work for creating space for students to actively contribute to how the science activities unfold and become contextualized.

The results of the dissertation show how the students' spontaneous interactions while working independently out of earshot of the teacher may support the purpose of learning sciences at least in three ways. First, the cultural resources of non-conceptual nature that the students draw on provide access to everyday ways of being in the world that are not integrated in the science task per se. Humor, abuse and derision are typical and inherent means to relativize the abstract and overturn the institutional powers (Bakhtin, 1984a). Parallelly, intuitive, bodily and self-evident facts of the lived world form the foundation on which understanding the world relies (Husserl, 1989; James, 1907), and narrative interpretations have primacy in presenting, understanding, and interpreting everyday cultural life (Bruner, 1986; Ricœur, 1991). Thus, all these observed interactions make connections to primary relations and knowing one's way around the world. By incorporating these experiences into doing science—even if only bringing the two together by simultaneously invoking both—students may transform science activities in ways that are culturally relatable and therefore affectively meaningful for them. As Vygotsky (1934/1987) stated, the flow of thought cannot be segregated from the fullness of life—the needs, interests, inclinations and impulses—of the thinker. Thus, making an emotional–affective (bodily) engagement is the first step toward the motivated intellectual engagement. Accordingly, a meaningful way of organizing subject matter resides in present experience and not in the intended objective of learning; this kind of organization "is free, not externally imposed, because it is in accord with the growth of experience itself" (Dewey, 1938/1997, pp. 81-82). Thus, supporting students as they make connections to their everyday experiences lays the foundation for facilitating conceptual learning.

Second, the findings exemplify how activities that initially may appear as off-topic may constitute fertile ground for later scientific understandings and knowledge. For example, Study II showed how students' physical explorations of the environment as well as narrative accounts that originated spontaneously without apparent purpose for learning were used to advance the scientific task later on. Again, these types of interactions have primacy in students' experiences rather than the cognitive-conceptual goals given by the teacher and ingrained in the tasks. This is so, because attaining new knowledge from the world is characteristically non-teleological; it is the primal experiences that shape our understanding of the world and the scientific knowledge is layered and developed based on these previous experiences (Husserl, 1989). There are calls for science education to take a non-teleological approach by foregrounding the students' possibilities to re-live the primal premises of historically formed abstract scientific idealizations (Roth, 2014). The results from this dissertation show how the spontaneous activities of students in less supervised learning settings may be incorporated in the actual science tasks and, thus, may serve the purpose of learning that is grounded into students' primary experiences, instead of being directed by the abstracted goals given beforehand.

Third, the spontaneous interactions were shown to serve the purpose of overturning the authoritative and serious dimensions of science teaching and to support coping with the following potentially negative emotions, such as frustration. Study II showed how students drew from humor, derision and abusive language and showed knowledge outside the science task when reacting to the teachers' evaluative messages as if the frustration could be coped with and the learning tasks continued. Whereas evaluative feedback or difficulties in completing tasks can lead to negative affect (Bellocchi, 2018; Brown & Melear, 2006), the present findings showed how the physical absence of the teacher allowed students to overturn the authoritative dimensions perceived in the evaluation and cope with the potentially negative emotions while improving in the task in cognitive-conceptual ways.

In all, the results from Studies I and II suggest that the aim to shift from monologic forms of teaching towards the emphasis of dialogical interaction and students' perspective can greatly benefit from taking account the diversity of cultural resources that are available for the students from their everyday lives. When promoting opportunities for students to draw on their everyday experiences, science education research seems to have an emphasis on knowing and conceptual connections. For example, incorporating everyday knowledge into science learning may be considered

to be the origin of misconceptions (Vosniadou, Vamvakoussi, & Skopeliti, 2008), and the cultural resources from which students draw on in their everyday lives turn out to be inadequate to enable full participation in science education (e.g., Aikenhead, 2001). The findings from this dissertation show how the non-conceptual experiences work as means to access doing and learning science in ways that are affectively meaningful as they constitute the cultural and bodily premises of understanding the world. Here, the research exemplifies how the experiential engagement with science learning may escape the normative approach of science education from the perspective of knowing science. Consequently, this dissertation answers the call for dialogical and agentic learning opportunities by showing how meaningful experiences can emerge from the non-conceptual cultural resources by means that are mostly controlled by the students.

In contrast to many existing studies investigating instructional approaches to support students in making connection with their everyday lives and science, the results of this dissertation show, in this respect, how less supervision and direct instructional encouragement can allow students access to science from their own perspectives and premises. Whereas the importance of the students' backgrounds and experiences have been highlighted in many socioculturally oriented studies (e.g. Gilbert & Yerrick, 2001; Levrini et al., 2019; Lidar et al., 2009), the focus has mostly been on how students react to the inputs from the instruction from their own backgrounds or how teachers' manage to invoke students' everyday cultural resources. In the present research what students draw on and make available to each other that is not expected or encouraged by the teacher can be observed. Again, none of the interactions discussed above were induced by the science content or the science task but took place spontaneously and simultaneously *despite* them (as discussed in more detail in the next section). The fact that they mostly arose in the physical absence of the teacher and from students' own experiences in the particular environment further demonstrates how students can make use of their familiar and primary forms of being in the world during science lessons in ways that would be hard to incorporate into instructional materials and tasks themselves. And while some of the observed interactions would be impossible to endorse in a typical classroom, the phenomena observed here are not alien to classrooms teaching. They belong to the very essence of participating in the (cultural) world, and even if some forms of interaction, such as those opposing the teacher, may not become visible in the classroom to the extent that they do in the less supervised setting in the outdoors, they still exist at least as a *potential* opportunity for the students.

Also, some aspects of what was observed in the complete physical absence of the teacher might be actualized even during the short periods when the teacher's back is turned; these moments that occur regularly also in the classroom (Mehan, 1979; Roth et al., 1999). During such moments, students have been shown to enter into discussions that the teacher is completely unaware of (Roth, 2009). All in all, the findings from this dissertation show that for some of the means for students to turn science learning into something that is affectively meaningful, the teacher is not needed and the case can be even the contrary: at times, the (momentary) absence of the teacher is required for student means of connecting to and coping with science learning to be accepted within their mutual interaction.

6.1.2 How off-topic transforms to on-topic—the double reversal of serious learning

Most of the ways observed in this dissertation in which students utilize their everyday forms of experiencing and relating to the world were, at first, effectively off-topic activities in terms of completing the tasks or achieving the academic goals of learning. Yet, the students participated in the given tasks and eventually completed or improved on them by also following the requirements specified by the teacher. As discussed above, the initially off-topic activities supported the purpose of learning by allowing affectively meaningful ways to contextualize and access science tasks and cope with the perceived authoritative dimensions of science. This leads to another observation of how the spontaneous interactions in the relatively loosely supervised setting might work for the benefit of learning.

Particularly in Study II, when students opposed and temporarily overturned the teacher's authority (and the paralleling authoritativeness of science), they directly diverged from the task at hand and questioned its importance. Yet, soon after they followed the teacher's requirements and continued with their tasks and eventually improved their performance. On the one hand, the students' actions may seem contradictory or exclusionary; they overturn the seriousness of science by opposing the requirements yet follow the teachers' advice and improve their performance. Or as observed in Study I, they overturn the seriousness of science tasks by ridicule, humor, and coming up with narratives and bodily explorations that had little to do with the tasks themselves. However, soon or even simultaneously, they attend to the task to complete it. On the other hand, following the work of Bakhtin (1984a), this reversal can be understood within the carnival sense as a temporary suspension of the official restrictions. Just like the feast and the carnival of the medieval time

occurred only momentarily and their "legalization was forced, incomplete, led to struggles and new prohibitions" (p. 90), the students, after being distracted from the task, engaged in it and improved it following the teachers instructions that they had just questioned. Thus, what starts as off-topic activities and reversal of the scientific requirements, appears to be *double reversal* and eventually works towards improving students' academic performance. In a previous study, the same kind of double reversal was observed in a science class in which the laughter, invited by the teacher's humor, momentarily suspended the opposition between the science teacher and students and thereby both overturned and reinforced the seriousness of science learning (Roth et al., 2011). In the present research, however, the students' freedom, that arose from the physical absence of the teacher, moved the initiative on the students' part. It was the students who decided when and how to turn to the carnival sense of life and oppose the teacher or draw on the everyday lives. And it was also the students who decided when the time was right, to get back to the task and follow the academic demands.

In this regard, the findings from this dissertation show how the mutually exclusive separation of "on-topic" and "off-topic" activities does not reflect the complexity of the actual interactions during learning situations. It has been shown that participation in academic tasks is not a one-dimensional concept that alternates between being in the center (on-topic) or margin (off-topic) of the desirable activity; rather, participation is a dialectical concept in which the actions are positioned in and constitute the margin and center at the same time (Goulart & Roth, 2006). The authors show how the children's participation in science activity transformed away from the intended forms of participation but in a moment returned to engagement in the activity, the process ultimately contributing resources for new types of profitable activities. Thus, participation is a complex unit that always contains contradictive options that transform it towards the center or the margin of the intended activity. This dissertation builds up the understanding about how participation and engagement in science tasks can be constituted by alternating the marginal and central participation so that both function for the benefit of learning. The "off-topic" activities, even if initially marginal participation in respect of intended learning goals, contain opportunities for turning the participation in science task meaningful through several ways. For one thing, the spontaneous interactions constitute a culturally and affectively meaningful ground for science tasks to be accessed from. Furthermore, the double reversal or the seriousness of science allow the authoritative requirements and consequent frustrations to be managed and put temporarily put aside by students. The

findings from this dissertation show how all this can contribute to transforming the science tasks and teacher's demands to affectively more accessible forms of participating in and engaging with learning. The experience of agency arises from the capacity to transform the available sociocultural recourses to create new forms of activity (Goulart & Roth, 2006). This dissertation shows that, when working in the physical absence of the teacher, students can—in a truly agentic manner—draw from the contradictions experienced between the requirements to complete the tasks and activities diverging from the tasks to transform and reinterpret the activities. Through this transformation they create new forms of participation in doing/learning science that stem from the full spectrum of their life experiences instead from merely the task itself.

The above implies that whereas science educators might interpret any "off-topic" activity as harmful for learning or deviations from the normative classroom order or as manifestations of disciplinary problems and antiacademic behaviors (e.g. Arens et al., 2015; Phelan et al., 1994), the case is not that straightforward. This dissertation shows that, provided that the students have enough reasons to engage with the science tasks (see the next section), by considering everything outside off the academic topic as a harmful distraction, researchers and educators ignore valuable opportunities that arise for students for engaging in learning activities. In this respect, the present findings show that the importance of providing students with opportunities to express their own knowledge, views and identities in dialogical exchanges does not limit the aims set by the teacher. On the contrary, it extends opportunities to draw from the fullness of their experiences to the students and even oppose what is expected from them. These experiences constitute the foundation of any meaningful learning, and they emerge in ways that neither a teacher nor a student could know beforehand (Roth & Jornet, 2014). In this regard, science educators may find benefits from providing students the moments of freedom and momentarily turning their back on them. For the "off-topic" activities to be perceived as a potential for meaningful experiences that can be transformed into participation in science tasks, one needs to make sure that the academic goals remain as the eventual focus of the students. Yet, accepting the full affective and cultural spectrum of the students' lives as the starting point of any meaningful learning experience shows to be more important than making a clear distinction between what is "off" and what is "on" topic during learning processes.

6.2 Objective 2: To study the instructional practices and pedagogical choices that allow the balance to be shifted from control towards less supervised learning settings.

Taking account of the results from all three studies, the dissertation provides evidence for how it is possible to provide less supervised instructional structures within which the students can temporarily gain a sense of freedom and utilize it for actualizing an affectively meaningful and manageable relation with science learning. The findings from Studies I and II showed how the physical absence of the teacher provided students with interactional opportunities that might be considered off-topic, chastised and considerably limited in typical a classroom interaction; yet, it was shown how these could support the purpose of learning by contextualizing activities and experiences in meaningful ways or by helping students to temporarily overturn the authoritativeness of science teaching. To understand the premises of these processes from the teacher's perspective, Study III revealed important aspects about the pedagogical choices, goals and instructional practices behind the particular, less supervised, outdoor settings.

The findings from Study III showed how the teachers who used outdoor education extensively emphasized students' sense of freedom and autonomy—as well as the positive and trusting relationship between the teacher and the students—as a part of scientifically and affectively authentic experience of learning outdoors. Indeed, as Studies I and II showed, the small amount of physical presence of the teacher, and direct supervision thereof, allowed students to shift from science tasks to "off-topic" activities and vice versa. At the same time, the certain controlling aspects and structures that functioned to institutionalize outdoor learning are needed to endorse and ensure students' commitment to science activities. That is, whereas the freedom allowed the affectively valuable interactions to be (visibly) manifested, other controlling aspects of the instructional setting and teachers' choices—such as well-planned tasks, assessment and communication through mobile phones—were perceived as being pivotal for the students to make efforts to complete their academic tasks. The observations of the students showed how this was manifested; overall, the students made an effort to follow the requirements, and improved their performance along the course of the lessons even if they were temporarily distracted from the tasks.

In this regard, the dissertation provides evidence how it is possible to provide instructional structures within which the students can temporarily gain a sense of freedom while the teachers experienced having enough

control. Teachers tend to fear the loss of control (Glackin, 2017). They even implement classroom-like forms of interaction even outside of the classroom where the interaction might naturally be less supervised, while the opposite is suggested to be beneficial (Rajala & Akkerman, 2019; Rea, 2008; Tal et al., 2014). The findings from this dissertation show how the controlling aspects do not arise from controlling the immediate interaction with the students, but the choices and structures that institutionalize the exceptional learning setting are more subtle. For example, emphasis on the regularity and executing regular assessment, enabled the teachers to provide control while at the same time actually decreasing supervision and direct control in the interactional setting of the lessons. This is contrary to the many studies suggesting that the teachers seek to achieve control through controlling the interaction in ways that usually decrease opportunities for authentic dialogues (e.g. Aquiar et al., 2010; DeWitt & Hohenstein, 2010). The emphasis in existing research seems to be on the structures and support to which students react and adapt. On the contrary, the present findings suggest that the balance between control and freedom can also be achieved through means that do not hamper the dialogical nature of less supervised settings as much as typical formal classroom structures might do. Thus, the ways to balance between control and freedom provide answers to the requirements of not imposing too many formal structures on learning settings when they could hamper the spontaneity and authenticity of the learning experience.

As shown in Study III, the outdoor teaching practices where the opportunity of the students to diverge from the task happened within the institutionalized setting which has been legitimized for the students and to which the students have been habitualized (Berger & Luckmann, 1966). Studies I and II showed how the "off-topic" activities were manifested within the sense of carnival freedom that was only the temporary and followed by even greater obeyance to the legitimized order—manifested in teacher requests. This notion is pivotal to the process described in this dissertation of how less supervision might work for the benefit of learning. Yet, as Bakhtin (1984a) showed, the carnival freedom and the related (grotesque) humor allow culturally natural ways for people to act within the tensions between authoritative institutions and everyday lives. By showing how shifting the balance of outdoor teaching practices towards less supervision can both work in practice and contribute to affectively meaningful learning, the present dissertation suggests that educators and researchers should pay more attention to the moments when students are distracted from the actual tasks. If adequate participation in the academic tasks is ensured through certain controlling structures and practices,

students can make use of the temporary freedom in ways that might not be foreseen or urged by the teacher. Thus, educators need not think unconditionally negatively about moments when students are drawn to off-topic activities. When they are considered from the perspective of being an important part of students' lives as any other activity, educators, as well as researchers, might find that what initially is "off-topic" can turn out to be "on-topic" when given proper space and instructional structures. At the same time, the dissertation provides tangible guidelines for teachers to plan learning settings in which the control and freedom are feasibly balanced and support the purpose of learning.

In all, this dissertation shows how the moments that might be perceived as "loss of control" may appear to students as affectively important ways to engage in the learning tasks while maintaining a sense of control of their own. The examples used in this research were from outdoor learning environments in which the students' freedom and access to independent interaction many times apart from the teacher was apparent. Yet, the similar moments of temporary freedom occur in other learning settings including the classroom. Only by the teacher momentarily turning away from the students, can the typical procedures be altered (Mehan, 1979). For example, Roth (2009), as well as DaSilva Iddings and McCafferty (2007), analyzed instances of group conversations that happened in the classroom but completely without the teacher's awareness. Both studies showed that during these moments, the topics of the conversations arose from the students' lives outside the school rather than from the tasks they participated in. This dissertation shows that while affectively meaningful experiences can emerge during such moments of freedom, they can be followed by engagement in the tasks even without the direct supervision by the teacher.

The present findings encourage educators to consider the potential of temporary deviations from the task from the perspective of what they mean for the students, not merely in regard of the intended task. Science education research repeatedly promotes student-centered approaches, inquiry and scientific practices as well as opportunities for choice and autonomy (Crawford, 2014; Schmidt et al., 2018; Stroupe, Caballero, & White, 2018). Also, taking learning out of the classroom, such as outdoors, is suggested to have positive affective and cognitive gains (e.g. Rajala et al., 2016; Resnick, 1987; Tal et al., 2014). Typically, instructional approaches that tend to increase students' choice and responsibility, such as performing inquiries, are evaluated and criticized depending on how well they support conceptual learning (e.g. Kirschner, Sweller, & Clark, 2006). This dissertation suggests that the support for planning instructional

settings where students' choice and autonomy are important may also lie in students having more opportunities to draw from something that seemingly has not much to do with the academic tasks. Hence, the carefully structured but less supervised learning settings may provide a valuable opportunity for shifting the approach in science education from what is dictated and aimed at in the conceptual learning goals set by the teacher to how students themselves make meaning of the process of learning.

7 Implications for science education and emerging lines for future studies

This dissertation draws from a broad range of sociocultural perspectives to show how the approaches to study and develop educational settings can benefit from acknowledging the full range of affective, bodily and cultural experiences that are manifested in lessons. Whereas much of the current research aims to promote affective and conceptual learning through its emphasis on instructional support to which students react and adapt, this dissertation makes a shift towards acknowledging how students themselves can come up with ways to access and participate in science learning in affectively as well as intelligibly meaningful ways. For this shift to make sense in educational implications and education research, it is crucial to acknowledge students' experiences and actions as being meaningful through and through. This is so because they are all reasonable within the fullness of students' lives at the moment they occur, not only in terms of how they reflect the academic and institutional goals of teaching (c.f. Roth & Jornet, 2014). When this notion is taken seriously, interesting and important implications for science education as well as lines for future research arise.

7.1 Practical implications of acknowledging the fullness of life as the foundation of meaningful science teaching

Students' alienation from (science) education is a major concern (Lyons, 2006; Säljo, 2004). This dissertation contributes to answering this challenge by adding to the current understanding of what students themselves might draw on to make doing science more meaningful. The research shows how activities that teachers might consider merely "off-topic" and distractions from the tasks, may serve as potential opportunities to actually participate in science learning in ways that stem from the full spectrum of culturally relatable experiences for students. This bears implications for both relating to students' initiatives and instructional practices in loosely supervised settings, especially in the outdoors.

First, science teachers may learn from the findings in this dissertation about acknowledging students' own potential in transforming their participation in science tasks in ways that are out of teacher's reach. Teachers should be sensitive not to straightforwardly chastise all "off-topic" activities as harmful but realize that they are meaningful for students.

If students can make use of a variety of means that do not stem from the academic goals as opportunities for accessing the learning, teachers should also look more eagerly for ways to connect—or allow students to connect—the everyday forms of experiencing the world, such as humorous, narrative and bodily accounts, to doing and learning science. Furthermore, students experience emotions of frustration in science education, especially in inquiry-oriented science lessons when they are faced with uncertainty of the correct answer or the right way to proceed (Brown & Melear, 2006; Gormally, Brickman, Hallar, & Armstrong, 2009). In this dissertation it has been suggested that educators may find it useful to enable students to cope with these frustrations during less supervised moments when they can even criticize the tasks or the teacher without causing too many disciplinary problems. Designing tasks in which guidance and further instructions can be given through remote means such as mobile messages may prove to be preferable from a direct form of guiding for the reason that it allows students to retain a sense of freedom and agency and cope with the authoritative dimensions of the requirements in their own ways, some of them unattainable in the presence of the teacher. By these means, teachers can require correct answers and assess them even without much direct supervision while at the same time allow students to mitigate the potentially alienating dimensions that these requirements bear (Sharma & Anderson, 2009).

Second, teachers may learn from the dissertation what to consider when developing and managing loosely supervised learning settings, particularly outdoor learning, in formal education. In this regard, the balance between freedom and control, and between choices and given structures, appears to be pivotal. Successfully applying outdoor learning environments depends on certain strategies that retain the loosely supervised nature of the setting while, at the same time, the teaching practices are institutionalized to have enough resemblance with formal school structures. To make such atypical learning settings work in practice, teachers will find it important to explicitly justify them for the students and invest in regularity that allows students to get accustomed to studying in such setting. Forms of control, such as assessment practices and well-structured tasks may prove to be necessary. But at the same time, willingness and courage to grant students more sense of freedom has benefits by building trusting and positive relationships with the students and inducing authentic experiences in and with the outdoor environment. In this way, shifting the balance from tight control towards less supervision may prove to be beneficial in unexpected ways. The relative freedom actually allows students to work towards meaningful participation in science learning—something that teachers

might typically want to ensure by controlling the interaction even in outdoor settings (Lavie Alon & Tal, 2017; Rajala & Akkerman 2019).

All in all, the material in the dissertation suggests they need to not fear losing control as much as they do (Glackin, 2017), provided that they make unsupervised learning settings into a common practice through certain structures. Instead, teachers should implement only the necessary amount of control for students to complete the tasks while taking advantage of the opportunities granted by loosening the supervision. Learning tasks in an outdoor setting represent the scientific practices and elevated level of students' choices, both of which are suggested to be promoted in science education (e.g. Crawford, 2004, Schmidt et al., 2018). In general, the findings from this dissertation encourage educators to develop instruction, both in and outside the classrooms, through which students take the initiative in how they make progress with the task.

7.2 Taking seriously the students' perspective on learning science in future studies

In this dissertation, the perspective has been moved from conceptual knowing of science and doing science activities towards what is manifested in student's lives during science lessons. By exemplifying how students use the variety of interactions that are seemingly unrelated to science to actually participate in science learning, this research suggests that everything that happens in science lessons can be potentially relevant even for the purpose of academic learning. Students' personal (and interactional) experiences in any learning situation include the whole spectrum of their cultural understandings, personal motivations and emotions as well as bodily and common-sense understandings of the world. This fullness of life cannot be separated from the cognitive side of learning (Vygotsky, 1934/1987), and it should not be excluded from the educational research either. Yet, the existing research repeatedly puts emphasis on the cognitive-conceptual side of thinking when exploring students' perspectives and voices. If a student is distracted from a task or opposes the teacher, it is rarely acknowledged as an important perspective from the student's side that could contribute to learning. Nonetheless, whatever is initiated by a student during a lesson has some importance for that student at that very moment—otherwise it would not be initiated.

The findings from this dissertation raise the need to understand better the complexity of students' opportunities and means to navigate within the contradictive demands of science learning and what they experience as familiar and important. This research was an investigation of carefully

structured but loosely supervised outdoor settings in which students had plenty of opportunities to react and interact that were dependable on the absence of the teacher. Yet, parallel moments of temporary freedom occur when a teacher merely turns their back on the students in classrooms (Mehan, 1979). Students' needs for agentic experiences or coping with authoritativeness expand beyond any particular setting, and so do the available means for pursuing these needs—both constitute fundamentally cultural phenomena. Future studies should investigate how similar phenomena could be better encountered within interactional settings in which the teacher is present. How can teachers take better account of the fullness of students' experiences and also provide space for students to participate from outside the intended course of action? For example, studies on instructional practice can further investigate how mobile communication may serve as means to enable dialogical interaction that both ensures the instructional requirements to be delivered and the perceived authoritative dimensions moderated. Moreover, future studies should investigate classroom settings in terms of how students can react to perceived authoritativeness, bring out their experiences of frustration or draw from culturally meaningful and familiar ways of experiencing the world while adjusting their behavior to the regulated and restricted interactions of the classroom.

The focus of Studies I-II provided understanding of the phenomena in regard to how they appear in science education and contribute to developing it, particularly addressing the calls to mitigate students' alienation from science. From the methodological stance, these studies exemplify how phenomena that might remain hidden in a typical classroom, where they would be objectionable, become visible when students are observed and recorded out of earshot of the teacher. As the parallel phenomena exist also within a classroom, a need arises for future studies to pay attention to and obtain data from interactions that occur outside the official agenda of science lessons, and even completely outside lessons.

Study III investigated the discursive accounts of teachers concerning the particular loosely supervised outdoor learning setting. However, students' accounts of the observed phenomena remain mostly unaddressed. Future studies should investigate how students find the exemplified opportunities that arise within their mutual interaction and how they consider the tensions between their tendencies to react and what is expected of them. The materials analyzed for Studies I-II were gathered from a group of students who were not particularly interested in science, based on the indications from the interviews (see Chapter 4.2). In other reported cases of

phenomena comparable to those described here, the students were attending an academically oriented private school and subsequently went to study in the STEM fields at the university level (Roth, 2009). The phenomena are not exclusive to students of a certain kind of academic orientation but are at least potentially shared by all as they are grounded in the cultural understanding of the world. Yet, future studies investigating the prevalence of the phenomena that described here could suggest that they occur more frequently among those who are traditionally less interested and lower-achieving in science. As these students are at the most risk of becoming alienated from (science) education, understanding how the alienation can be mitigated in their cases, is all the more important.

In conclusion, this dissertation exemplifies how education research can approach the manifestations of the fullness of life in the students' experiences during science lessons. The research shows tangibly how these manifestations can contribute to the engagement in science learning by making it affectively meaningful for the students. Here, the dissertation follows and actualizes the calls for taking students' emerging experiences—in the fullness of their affective and intellectual dimensions—as the foundation of studying the process of learning (Roth & Jornet, 2014). If researchers are not willing to take account of everything that is happening in the classrooms as potentially being important, there is a risk of ending up focusing only on the phenomena that are wanted to be observed and thereby disregarding something that actually makes the most sense for the students.

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Appendices

APPENDIX 1.

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

TUTKIMUSLUPA 9.8.2016

Maasto-opetus luonnontieteiden oppimisessa -tutkimushanke

Arvoisa huoltaja,

Helsingin yliopiston Opettajankoulutuslaitoksella toteutettavassa väitöskirjatutkimuksessa tutkitaan maasto-oppimisympäristöjen hyödyntämistä luonnontieteiden ja biologian opetuksessa. Tavoitteena on saada ulkona maastossa tapahtuvasta opetuksesta uutta tietoa, jonka avulla uusien opetussuunnitelmien mukaista koulun ulkopuolisten oppimisympäristöjen hyödyntämistä voidaan kehittää. Tutkimuksen kohteena on syksyllä 2016 Vesalan peruskoulun biologian kursseille osallistuvat oppilaat. Kurssilla opiskelu on normaalia koulun opetussuunnitelman mukaista oppilaiden opiskelua.

Tutkimukseen liittyviä oppitunteja videoidaan. Lisäksi oppilaita haastatellaan kurssin aikana kyselylomakkeilla ja suullisesti siitä, miten he kokevat opiskelun ja mitä he ovat oppineet.

Oppilaat tai koulu eivät ole tunnistettavissa tutkimusjulkaisuista. Videotallenteita käytetään ainoastaan tutkimuskäyttöön Helsingin yliopiston Opettajankoulutuslaitoksella. Materiaalia ei julkaista. Videotallenteet säilytetään Opettajankoulutuslaitoksen tiloissa. Alle 15-vuotiaiden oppilaiden huoltajilta tarvitaan lupa tutkimukseen osallistumiseksi. 15 vuotta täyttäneiltä oppilailta riittää oppilaan oma suostumus osallistumisesta, jolloin tämä kirje on huoltajille tiedoksi. Vastaamme mielellämme kysymyksiin tutkimusta koskien.

Helsingissä 9.8.2016

tohtorikoulutettava Anttoni Kervinen
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Professori Anna Uitto,
biologian opetuksen tutkimusryhmä (anna.uitto@helsinki.fi, p. 050 4482511)

saa osallistua tutkimukseen ☐
ei saa osallistua tutkimukseen ☐

Oppilaan nimi

Videomateriaalia tai valokuvia, joista oppilaita voi olla tunnistettavissa, voidaan käyttää tutkimuksen esittelytarkoituksessa tieteellisissä konferensseissa ja seminaareissa tai opetustarkoituksessa yliopistokursseilla, jos siihen annetaan erikseen lupa.

Saako kuvamateriaalia oppilaasta käyttää	kyllä	ei
- tutkimuksen esittelyn yhteydessä?	☐	☐
- opetustarkoituksessa yliopistossa?	☐	☐

Huoltajan nimi (jos oppilas on alle 15 vuotias)

Päiväys ja huoltajan allekirjoitus

APPENDIX 2.

Haastattelurunko, maasto-opetus & tutkimuksellisuus

Taustatiedot:

Kuinka pitkä ja millainen kokemus sinulla on biologian opettamisesta?

Minkälainen koulutus sinulla on?

Kuinka usein biologian opetukseesi kuuluu maastossa työskentelyä?

Minkälaista maastossa tapahtuvaa opetusta olet toteuttanut?

Maasto-opetus biologian opetuksessa:

Mitä ajattelet maastoympäristöjen hyödyntämisen merkityksestä biologian opetuksessa?

Kuvaile maastossa tapahtuvaa opetusta ja sen vaikutuksia ihanteellisessa tilanteessa? Millaisia tavoitteita siinä on silloin?

Minkälaisia haasteita maasto-opetukseen liittyy?

Mikä merkitys suunnittelulla ja jälkikäsittelyllä?

Miten arviointi liittyy maasto-opetukseen?

Miten käsityksesi maastossa-opettamiseta on kehittynyt?

Minkälainen koulun merkitys on maasto-opetuksessa?

Tutkimuksellisuus:

Uusissa opetussuunnitelmien perusteissa puhutaan luonnon tutkimisesta, tutkimuksellisuudesta, tutkivasta oppimisesta ja omien tutkimusten tekemisestä. Mitä tämä mielestäsi tarkoittaa biologian opetuksessa?

Minkälaisia tavoitteita tutkimusten tekemisellä ja tutkimuksellisuudella on?

Minkälaisia oppimistavoitteita siihen liittyy?

Mitä tällaisten tavoitteiden saavuttaminen edellyttää?

Minkälaisia haasteita tutkimiseen ja tutkimuksellisuuteen liittyy?

Ovatko tutkimukset ja em. tavoitteet tärkeitä, kun mennään biologian tunnilla ulos tai maastoon? Miten ne ilmenevät maastossa?